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American Gas Institute*

American Gas Institute



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# **PROCEEDINGS**

**OF THE**

## **American Gas Institute**



**NINTH ANNUAL MEETING**

**OCTOBER 21, 22, 23, 1914**

**NEW YORK, N. Y.**



### **Part I**



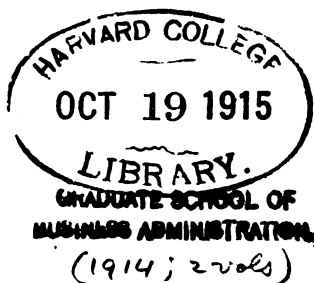
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*W. H. Gantley.*

**PRESIDENT**

Report of the Proceedings  
of the  
**American Gas Institute**  
**Ninth Annual Meeting**

held at  
New York, N. Y.,  
October 21, 22 and 23, 1914.

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**INSTITUTE MEETING.**

**Morning Session, Wednesday, October 21.**

The ninth annual meeting of the American Gas Institute was called to order in the auditorium of the United Engineering Societies' Building, New York, October 21, 1914, at 10 A. M. sharp by the President, Mr. William H. Gartley, Mr. George G. Ramsdell being in the Secretary's chair.

Upon motion, the reading of the minutes was dispensed with.

**THE PRESIDENT:** The first business is the report of the Board of Directors.

The Secretary then read the

**REPORT OF THE BOARD OF DIRECTORS.**

The Board of Directors, at their meeting held Tuesday, October 20, approved the following reports:

Secretary and Treasurer,  
Technical Committee,  
Public Relations Committee,  
Revision of Constitution.

In regard to the last report, we call attention to the fact that in Section 23, the word "two" was taken out, making the section read, "The Board of Directors shall consist of the President, the Vice-Presidents, the Secretary, etc." A change was made in Section 10, to make it read: "The Secretary shall submit each application to the Membership Committee, who shall consider and act upon it, and assign the applicant to the grade and membership to which, in their judgment, his qualifications entitle him. The name of each candidate thus approved by the Membership Committee, unless objection is made by the applicant, shall, after approval by the directors, be submitted to the voting membership for election by means of a letter ballot."

The Board recommended that the matter of changing the By-Laws to conform to the revised Constitution, if adopted, be referred to the incoming Board of Directors.

The Board approved the papers to be read at this meeting.

The Board also suggested that a committee be appointed to take up the matter of affiliation with state and other gas associations, with a view to enlarging the scope of the work of the Institute, particularly in connection with the work of the Public Relations Committee.

## REPORT OF THE SECRETARY AND TREASURER.

### REPORT OF COMMITTEE ON SECURING NEW MEMBERS.

The list of new members elected during the year has been as follows :

On the March ballot—

Active.....	51
Associate.....	17
Junior.....	36
	— 104
Transferred to active.....	3

## On the September ballot—

Active.....	39
Associate .....	11
Junior.....	23
	— 73
Transferred to active.....	1
	177

G. T. MACBETH, *Chairman*,  
 G. G. RAMSDELL, *Secretary*,  
 W. S. BLAUVELT,  
 PAUL DOTY,  
 AUSTIN BURT,  
 H. L. RICE.

(The names of the members elected on the March and September ballots are not shown here, as they are indicated by the letter "N" on the membership list at the end of Part II.

The list of members present at the meeting will also be found in the same list, designated by the letter "P.")

## TREASURER'S REPORT.

2nd October, 1914.

MR. WILLIAM H. GARTLEY, *President*,  
 American Gas Institute,  
 29 West 39th Street.,  
 New York City.

DEAR SIR:

I have the honor to report that I have audited the cash accounts of the American Gas Institute for the period of 12 months ended 31st August, 1914, and have found the same to be correct.

I verified that all receipts for the entire year as shown by the cash book had actually been deposited; that all disbursements have been duly authorized and were covered by properly approved vouchers; and further tested the correctness of the payments by examining certain of the vendors' invoices. A certificate was obtained from the bank confirming the balance on deposit as shown by your records as of 31st August,



1914. The petty cash on hand was counted and found to be correct.

In addition to the detailed audit of the cash, comprehensive tests were made of the subsidiary records, and I was fully satisfied as to their accuracy.

In my opinion the annexed schedule presents a correct statement of the cash receipts and disbursements of the period under review.

Very truly yours,

CHESTER P. CHILD,  
*Certified Public Accountant.*

# AMERICAN GAS INSTITUTE. COMPARATIVE STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS.

Periods of twelve months ended 31st August 1914 and 1913.

	Period ended 31st August, 1914	Period ended 31st August, 1913
Balance on hand at commencement of period	\$ 4,313.82	\$ 3,273.86
<i>Receipts:</i>		
Dues:		
Arrears.....	\$ 1,585.00	\$ 1,420.00
Current .....	12,120.00	10,950.00
Advance.....	20.00	40.00
Initiation Fees .....	\$13,725.00	\$12,410.00
Sales: Gas Institute News.....	1,970.00	1,945.00
Bulletin of Abstracts .....	\$2,987.13	2,574.00
Proceedings .....	1,797.42	1,341.75
Badges .....	527.00	579.42
Badges .....	79.75	63.00
Miscellaneous.....	877.88	1,163.25
Rent (Society of Gas Lighting).....	6,269.18	5,721.42
Interest on bank balances.....	60.00	60.00
	153.45	199.86
Total receipts for period.....	22,177.63	20,336.28
	\$36,491.45	\$23,610.14
<i>Disbursements:</i>		
Office Expenses:		
Salaries:		
Secretary.....	\$3,999.96	\$3,544.54
Assistant to secretary .....	1,160.00	1,080.00
Stenographer.....	698.00	590.00
Rent of office and storeroom .....	1,917.95	1,658.00
Supplies, equipment, postage, etc.....	946.43	930.26
Telephone and telegraph.....	163.02	136.71
Library .....	16.60	11.66
Insurance .....	40.00	51.20
Miscellaneous .....	235.69	167.12
	\$9,177.65	\$8,169.49
Balance on hand at commencement of period and total receipts carried forward .....	\$26,491.45	\$23,610.14
Disbursements carried forward .....	\$9,177.65	\$8,169.49

# AMERICAN GAS INSTITUTE. COMPARATIVE STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS.

Periods of twelve months ended 31st August, 1914 and 1913. — (Concluded.)

	Period ended 31st August, 1914	Period ended 31st August, 1913
Balance on hand at commencement of period and total receipts brought forward .....	\$ 9,177.65	\$ 8,169.49
Disbursements brought forward .....	\$26,491.45	\$23,610.14
<i>Disbursements:—(Concluded.)</i>		
Publishing and Distributing:		
Proceedings .....	\$ 6,294.52	\$ 3,421.69
Gas Institute News .....		
Supplements .....		
Prizes .....		
Bulletin of Abstracts .....	\$4,344.18	1,626.90
Advance Papers .....	1,629.92	1,599.04
Certificates .....	886.42	2,042.50
Merchandise .....	56.60	176.75
	518.74	488.48
	13,730.38	9,355.36
Meetings and Miscellaneous:		
Expense annual meeting .....	\$1,157.99	
Less, refunded by committee on arrangements .....	975.79	
Reporting .....	\$182.20	
	734.55	
Reporting (directors' meetings) .....	\$916.75	\$385.54
Stationery and expenses—committees .....	379.91	376.50
Badges .....	254.53	225.13
Gas Congress .....	2.00	374.00
Educational fund .....	205.00	20.65
International Committee on Illumination .....	500.00	350.00
National Fire Protection Association .....	100.00	
Refunds .....	25.00	
	9.00	39.65
	2,392.19	1,771.47
Total disbursements for period .....	\$25,300.22	\$19,296.32
<i>Cash Balance at End of Period:</i>		
Columbia Trust Company .....	\$1,141.23	4,263.82
Petty cash on hand .....	50.00	50.00
	\$1,191.23	\$4,313.82

## STATEMENT OF OUTSTANDING ACCOUNTS.

## Delinquents for one year's dues, ending August 31, 1914.

Active,	78 @ \$10.00.....	\$780.00	
Associate,	9 @ 10.00.....	90.00	
Junior,	22 @ 5.00.....	110.00	\$ 980.00

## Delinquent for two years.

Active,	42 @ \$20.00.....	\$840.00	
Associate,	7 @ 20.00.....	140.00	
Junior,	4 @ 10.00.....	40.00	1,020.00

## Delinquent for three years.

Active,	31 @ \$30.00.....	\$930.00	
Associate,	14 @ 30.00.....	420.00	
Junior,	6 @ 15.00.....	90.00	1,440.00

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\$3,440.00

Owing for Bulletin of Abstracts..... 45.00

Unpaid miscellaneous sales..... 802.53

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\$4,287.53

## MEMBERSHIP REPORT.

Total members September 1, 1913..... 1,471

New members elected..... 177

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1,648

Members deceased..... 13

Members resigned..... 62

Members dropped for non-payment..... 51

Did not qualify..... 2

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128

Total, August 31, 1914..... 1,520

## SECRETARY'S REPORT ON BADGES AND PROCEEDINGS.

Badges on hand September 1, 1913..... 140

Sold during year..... 22

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On hand August 31, 1914..... 118

Proceedings—Volumes 1, 2, 3, 4, 5, 6.

In stock September 1, 1913..... 1,159

Sold during year..... 33

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In stock September 1, 1914..... 1,126

Volume 7.

In stock September 1, 1913..... 325

Sent out and sold during year..... 47

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In stock September 1, 1914..... 278

## Volume 8.

Received .....	473
Sent out and sold during year.....	86
	<hr/>
In stock September 1, 1914 .....	387

## SUPPLEMENTAL REPORT.

## Cash statement September 1 to October 1, 1914.

Balance in bank September 1.....	\$1,191.23
Received for dues, etc.....	6,010.82
	<hr/>
	\$7,202.05
Disbursements .....	2,144.73
	<hr/>
Balance on hand October 1.....	\$5,057.32

## REPORT OF THE FINANCE COMMITTEE.

October 13, 1914.

*To the Directors of the American Gas Institute.*

Gentlemen: Enclosed please find the report of the Treasurer for the fiscal year ending August 31, 1914.

Your Finance Committee has had the books, accounts and statements of the Treasurer audited by Chester P. Child, Certified Public Accountant, and he has found the Treasurer's Report to be correct. We attach herewith a copy of the Auditor's Report.

It will be noticed that the certificate of the auditor is to the effect that he has audited the "Cash Accounts" of the American Gas Institute. The cash accounts may, and probably do, show fairly closely the income and expenditures for any year, but there is no certainty that this is the case and your committee would suggest that in the future the Treasurer's Report show, in addition to the actual receipts and expenditures, the income and expenses properly belonging to the fiscal period reported upon.

Assuming that the cash accounts do correspond fairly closely with the income and expenses it will be seen that during the last fiscal year the expenses exceeded the income by practically \$3,100. With a continuation of the existing conditions, it is

not probable that the income during the next fiscal year will exceed the income for the last fiscal year by more than \$700. Since the cash on hand was only about \$1,200 the Institute faces a continuing deficit, with no balance to draw upon, during the coming years unless the income can be increased or the expenses cut down. The latter result cannot be achieved without seriously curtailing the already too limited amount of work done by the Institute and therefore it is imperative that the income be increased.

This situation will be met by a recommendation of the Committee on the Revision of the Constitution.

Respectfully Submitted,

ALFRED E. FORSTALL, *Chairman*,  
C. H. GRAF,  
R. M. SEARLE.

THE PRESIDENT: The report of the Board of Directors includes the report of the Committee on the Revision of the Constitution. You will notice that this report has a place further down in the morning program. Changes in the Constitution must be voted on by ballot. To permit the election of officers for the year 1916 to be governed by the amended Constitution, the changes must be adopted this morning. Our Constitution, as revised, provides that the vice-presidents shall be elected from the various Sections, and that the Sections themselves shall nominate three names from whom the Nominating Committee will select the vice-presidents for the year 1916. If, therefore, we allow the vote on the revision of the Constitution to go until Friday morning, you will see that, the Section meetings being over, there will be no opportunity to select these names. Then again, we cannot accept any amendment to the report because the Constitution provides that any amendment shall first be voted upon by the Board of Directors, who will, after favorable vote, present it to the Institute. Therefore, I ask you to look over, and become acquainted with, the Constitution as revised, so that we can vote to adopt

the report as a whole or let the whole matter go over for another year. This we think would be unfortunate.

What is your pleasure regarding the report of the Board of Directors?

MR. PAUL DORY (St. Paul, Minn.): I move the adoption of the report of the Directors.

The motion was seconded and carried.

The President then called Capt. W. E. McKay, First Vice-President, to the chair, while he read his address.

### PRESIDENT'S ADDRESS.

Among the duties that fall to the lot of your presiding officer not one is more agreeable than that of welcoming you to the forty-second consecutive annual convention of the gas men of our country, a country still rich in the natural resources of our business, enjoying the advantages of peace, abundant products of the farm and field and factory, and a people well acquainted with the advantages of our product as a lighting and heating agent for domestic and industrial purposes. Fate has ordained that those countries whose people have shared with us in the building up of the technique and practical development of the gas business should now be engaged in a bitter and destructive conflict; and it becomes us in a chastened spirit of humility and thankfulness to extend to our contemporaries in these countries our sympathy, and particularly to the members of the Belgian Gas Association our extreme condolence that they should find their country devastated and its people wanderers because of a war in which they appear to have taken no initiative.

The Institute is now about to start its tenth year and it has seemed to me worth while to occupy your time by a brief review of how the Institute has performed the duties contemplated for it by the founders of its constitution. I should like, if time permitted, to read the address of that President of the Institute made at the first Convention after the Constitution was presented and adopted in its amended form. Quoting from his address, he said:

"It is not certain that our industry will profit from the change that we have wrought. We have destroyed three of the most useful organizations of practical and scientific men that have ever existed; we have abandoned the old simple form of organization, with the old unpretentious names; we are erecting a new and complex organization, with a name suggestive rather of confidence than of modesty."

He said :

"It is designed by the new Constitution to effect what I understand to be the determination of the membership of this Institute, to continue and extend the technical work of the late gas associations, and further to so conduct the affairs of the Institute that it shall be, and be recognized as being, the authority in the United States on all questions relating to the manufacture, distribution and utilization of gas, including the keeping of accounts, and the relations between gas companies and consumers and gas companies and the City and State. It is possible, by the exercise of care and deliberation, to so place this Institute that it will be universally recognized as an authority to which appeals may be made, with confidence that scientific accuracy and perfect justice will characterize its decisions. The existing agitation on the subject of public service utilities, their charges and service, and the variety of laws, regulations and standards proposed by the various States, indicate the importance of some recognized authority."

The Constitution provides that the work shall be conducted under three general headings :

1. The work of the Public Relations Committee.
2. The work of the Technical Committee.
3. The co-ordination of research work and the cultivation of intimate working relations between the State Associations and the National Institute.

The work of the Public Relations Committee has been con-



ducted in such a manner as to fulfill the purposes of the founders of the Constitution. It has become a recognized authority. It has created confidence in its scientific accuracy. Throughout the history of the Institute the work of the Public Relations Committee in conferences with the Bureau of Standards at Washington, investigations leading to the fixing of standards of quality, hearings before State Commissions, the reviewing of proposed regulations, the subject of workmen's compensation laws, and other laws affecting our business, is well known to many of you, although the modesty displayed in the reports of the Committee give too slight an indication of the value of their activities.

The Technical Committee may well claim to have performed all the functions that were assigned to it by the founders of the Constitution. The papers that are presented to the Institute, and which to a great number of the members constitute their most intimate association with the work of the Institute, are of a standard beyond adverse criticism. Our PROCEEDINGS constitute practically all that is published of American gas practice in every operation but the commercial work. The reports of the Institute's Committees on special subjects constitute the final authority on these subjects.

This Convention is the forum in which gas men meet for the presentation of ideas before a critical audience, and much might be said in detail of the far reaching effect that has been produced by the papers presented. I have in mind one comparatively simple, short, practical paper presented some seven years ago, of which the author has told me that no subsequent year has gone by since its publication that he has not received inquiries and discussions by mail from all parts of the country.

The great principle involved in the presentation of these papers is co-operation, as opposed to a narrower spirit of self interest. The President of the University of Wisconsin in a speech made last year, after expressing a realization of the fact that the success met in destroying the great combinations known as "trusts" had not resulted in bringing about what

was desired, *i. e.*, reducing the price of the commodity supplied through open competition, said :

“Co-operation is the cry of humanity in this Twentieth Century, and commerce should not be eliminated from sharing its great benefits. In our desire to retain legitimate competition, we should take care not to outlaw legitimate co-operation.”

My earnest advice to every member of this Institute who desires to place himself on record as having carefully and systematically set down a full knowledge of some detail of the business, or who wishes to have his mind emerge from a hazy general conception and “rule of thumb” ideas on some one subject, is to prepare a paper and submit it to the Technical Committee of the Institute. In no other way can a man better master a subject. In no way can he better determine for himself and others the scope of his ability in connection with the business.

As to the third general purpose of the work of the Institute in its relations to its affiliated State Associations, it may be said, and too hastily said, that the result of the 9 years of operation has failed to carry out, except in a very small degree, the ideals of the founders of the Institute. Four State Associations alone have formally affiliated themselves with the Institute, but the results of affiliation as outlined in the Constitution have not been realized.

It was intended that the Institute would confer with, and assign to, the State Associations some line of research to be carried on under the supervision of the Technical Committee of the Institute, and the State Associations were to make certain agreements as to the limitation of qualifications for membership; among these, that each association was to confine its membership to the district covered by the association.

It appears that for some unfortunate wording in the declaration of these purposes as given in the Constitution, or by some unfortunate misconception of the purposes of the Institute, the local associations have felt that the Institute was

endeavoring to curtail their liberties, to direct their activities and to assume a control over their procedure that they were not willing to grant. And yet I am confident that there are men now before me, strong advocates of the usefulness of the local associations, who are convinced that the work of the Institute has been of prime importance to the State Associations, and to the gas interests represented by those associations. Particularly do I refer to the work of the Public Relations Committee, who have been vigilant in watching the development of legislation and the trend of regulation by State Commissions in all portions of our country, whether or not represented by an affiliated association. It is my opinion that the idea expressed by the founders of the Institute in suggesting affiliation with the local associations will still be found to be one of great importance, and I would suggest that this matter be taken up now to determine exactly what can be done to bring about a closer bond between all of the associations.

I have had the thought that there might be combined with the headquarters of the Institute, a department which might be called a "Bureau of Statistics," supported by contributions from the State Associations, and who would work in conjunction with the Public Relations Committee in doing that work which can be done, as I see it, by the Public Relations Committee of the Institute alone, namely, the furnishing to the State Associations of data, information and arguments that have been presented to other Station Commissions in solving the same problems. I do not now intend to make that suggestion because other provisions, looking to an even larger degree of usefulness in the relations of the Institute with the State Associations, are under consideration.

The Institute represents the gas interests of the country and not the gas companies. The voting membership of the Institute is confined to individual members, employees of gas companies or of consulting experts in the gas companies' business, each of whom must be competent to act as a manager of

a department of a gas company, and who must have his principal interest in the manufacture, distribution and sale of gas, and be over 26 years of age. This body of men is necessarily limited in the United States, but it is that body of men who are most keenly interested in the development of the business and who are best able to judge how the technique of that business shall develop. There is no company membership in the Institute. No company can vote, and no combination of companies control its affairs. The expense of carrying on the work of the Institute is met from the annual dues, initiation fees and from the sale of its PROCEEDINGS, papers and publications.

Again, the Institute has not indulged itself in any campaign for new members in the modern sense of the word; the initiation fee has never been suspended and the dues are higher than those associations to which financial assistance is rendered through company membership. With no intention of making any unfavorable comparison with other organizations, nor to comment on their constitutional provisions, I hold that this spirit of independence that has been the marked characteristic of the American Gas Institute should be maintained to the end. Our business is to perfect ourselves in all the knowledge that pertains to our trade, through co-operation, and to protect the gas interests by furnishing accurate information based on scientific and practical experience by which no commission or other authoritative body can be misled.

The Institute is solvent at the present time, but for the fiscal year ending August 31, 1914, there has been a considerable depletion of its surplus, which has been reduced from a balance on hand August 31, 1913, of \$4,313.82, to a balance on hand August 31, 1914, of \$1,191.23. From time to time it is necessary to make considerable extra expenditures. The Institute is larger than ever before; is exercising an influence that is gradually increasing and it can scarcely be expected that the expenditures, if it is to fulfill its purposes, can be

maintained without increase. Larger expenditures are now necessary if the Institute is to maintain its present dignified and useful character. The offices of the Institute are not adequate for the work that is being done; they are crowded, and a room should be provided for frequent committee meetings, without upsetting the business of the office; and also accommodation should be made by which the Public Relations Committee may have an office for its secretary, connected with the headquarters of the Institute, that would be sufficiently large to hold the committee's records and file the data and information necessary for the performance of the committee's duties. It should be an office that will give an impression of the dignity and force of the committee's work. This is urgently needed. The records of this committee should be a part of the records of the Institute, and not be contained in the offices of the members scattered through several cities.

It has been important that the Institute should associate itself with certain other organizations and contribute to carrying out purposes well defined and bearing on our trade. Among these are the International Commission on Illumination and the National Fire Protection Association, and such combinations as are represented by our Committee on Electrolysis.

At the time of the first report of the Public Relations Committee of the Institute in 1907 in which they stated:

"That the change from the policy of open competition as a regulating force and secret accounting, to State Supervision and regulation with public accounting is not inimical to the interests of the owners of gas properties provided that it is accompanied by protection to the values of the properties supplying the public need. Such protection is as necessary to the public interest as to the corporations, since without it capital cannot be secured to make necessary extensions and improvements."

There were 3 states that had adopted State Commission control of public utilities. To-day 47 states and the District

of Columbia have followed their predecessors and, with one exception, all the States in the Union have now State Commissions for the regulation of public utilities; of these, 28 have authority to impose regulations on gas companies; 15 of the latter have published or adopted proposed rules, and 5 others are known to be formulating similar rules.

The result of this supervision by men of judicial minds whose business it is to become thoroughly acquainted with the operations of public utilities in order that justice shall be done to the public as well as to the capital invested in the companies, has developed several facts of interest. The first of these is that the gas companies, upon competent investigation on the part of the commissions, particularly after the commission has become well informed of the state of the art of gas making with its marked peculiarities not encountered in any other public utility business, have been found to have very little to condemn in the conduct of their business. If injury has been suffered by the public through the operation of other public utilities, the gas companies were found to have been conducting their business in an intelligent and careful manner, been maintaining good quality of gas and performing good service to their consumers.

Another fact is that the relations of the Public Utility Commissions, as they have developed year after year, have strengthened the position assumed by many gas engineers that the quality of gas delivered to the consumer in the great majority of cities was not only extravagantly high, but that a lower quality of gas in many cases would have given better service. This statement, appearing to the untrained mind as an absurdity, upon careful investigation has been proven to be correct. It has been held by engineers and experienced gas managers for some years that a gas of 570 heat units would, on the whole, for the numerous uses of gas, be more satisfactory than one of 600 heat units; but it was not until the last 2 years that any Public Utility Commission has felt itself secure enough in their position to set the standard so low.

A third and most important point has been made prominent. No country-wide general laws can be laid down regarding the quality that is at once applicable to every gas company's situation, but on the other hand the companies of each State must be examined as to their own local conditions by an experienced Commission. To attempt, for instance, to advise all State Commissions that some one standard of quality should be required of all gas companies is to court a loss of respect by State Commissions for the value of that source of advice. On the other hand, I believe that a State Commission should not yield to the temptation to impose more severe standards of quality on the more important gas companies within their control, and less severe on the smaller companies.

No Commission has yet adopted a photometric standard, but one has adopted a dual standard of calorimetric and photometric values, and this in Ohio is a peculiar case in which, owing to the large quantity of natural gas, they require 800 heat units for the natural gas, and 600 heat units and 12 candle-power for artificial gas. All Commissions so far fixing standards of value for gas have agreed that the gas should be measured according to its heating value.

And yet to-day there is more gas being made under candle-power requirements than under heat unit requirements. The causes for this condition are diversified,—existing municipal laws, contracts and inability to make changes quickly on the part of the gas companies under condition peculiar to the localities, and conflict of authority between State Commissions and municipalities are some of them. While each case must be decided on its own merits, it is believed that the country at large is coming to a heat unit standard.

On the whole, and I say this with full realization that some members of the Institute will not endorse my statement, the operation of the gas business under the regulation, inspection and control of judicial bodies, well informed as to the art of gas manufacture, distribution and sale, giving an opportunity to show not only by arguments, but by inspections and tests

the justice of their position and get decisions based thereon, is of advantage and would not willingly be changed by the gas companies. It has been helpful in taking the gas business out of the field of partisan interference and putting it on a stronger basis. Writers on economics now assert with confidence that public utilities, such as gas supply, are "natural monopolies." One Justice of the Supreme Court calls them "necessary monopolies," and the theory now meets with general acceptance that the supply of artificial gas in any district can best be conducted as a "natural monopoly," subject to State regulation. While we are accustomed to this idea in this year, yet how venturesome we would have considered a president of a gas company 10 years ago who dared, in the face of public sentiment, to maintain such an attitude.

The Wisconsin Commission states that all public utilities should be operated under an "indeterminate franchise," or "indeterminate permit," by which the public, either municipality or State, at certain times may purchase the plant and business under conditions which will secure to the company the right to appeal to the courts to get justice in the matter of value.

Perhaps, with fair dealing and open justice, a gas company would not be unwilling to be forced to sell to the municipality, and the idea of municipal operation still is attractive to many minds whose high degree of intellectual development is accompanied by a rather low standard of practical common sense. Without diverging into a discussion of this feature, it can be said that while the operation of utilities under State Commissions is generally believed to be as satisfactory an arrangement as has yet come within human purview, yet such objection to it as has so far appeared is due to the desire of municipalities to participate in the operation of the utilities within their boundaries. The officers and some of the citizens of the municipalities are, here and there, not content that in their dealings with public utilities they shall have a court of appeal provided, made up of men well informed and expert



in the workings of the utilities, but, being one party to the contract, they desire also to have some of the authority to control the other side by coercion, through local ordinances or breach of contract—a most unfair proposition. Statistics show with such overwhelming force that the chances of success of municipally operated public utilities are far less than those privately operated; that it would seem sufficient to convince the most sceptical; but the theory is an attractive one and will continue until some one is able to present the entire case in such a manner as to finally dispose of it. The three last Presidents of the United States have each declared his opposition to the governmental operation of interstate utilities.

The first Commissions in issuing regulations and general supervision over the affairs of gas companies no doubt felt their responsibilities resting heavily upon them. They were entering a new field of judicial procedure and were assuming executive functions, the practical effect of which was as uncertain to them as to the gas companies. The Wisconsin Commission issued its rules prior to 1907 requiring heating power standard, yet it was not until 1913, after an elaborate general investigation by the Engineers of the Gas Commission of the Second District of New York and the Empire State Gas & Electric Association, that it was known definitely by the gas men what difficulties and what possibilities of manufacture and distribution of gas lay in a heating power standard; and what is true of this one particular applies in general to all the relations between the State Commissions and the gas companies. With 48 Public Utility Commissions handing down decisions and rulings on all the intricacies pertaining to the business, the Commissions are now, and will be more so, hedged about with the great mass of precedents and opinions affecting their decisions and rulings, and these will gradually partake of a closer adhesion to prior decisions. An opinion or announcement of some new principle, acceptable to both sides, influencing the future of our business, may appear through the dealings of the States Commission with some

other public utilities, and in our own work the manager of a gas company, while endeavoring to comply with the Commission's rulings, will encounter such a mass of fine distinctions and apparent confusion of decisions that to any but the legal mind, specializing in this work, discouragement will follow bewilderment.

It becomes very desirable and necessary that these rulings and decisions of Commissions in their treatment of all public utilities shall be digested for us by competent legal authority and presented in such a way that the decisions of all the State Commissions will be indexed and annotated so that we may have with each decision reference to other previous decisions on the same point. The preparation of such volumes is a matter of great importance, and will require a considerable financial outlay. No decision by any State Commission can be trusted to. They are of merely local importance. The decisions of these Commissions must, if intelligently and fairly made, partake of much of the character of court decisions, established on the laws of the State and based on the powers of the Commissions and modified by their previous rulings and those of other Commissions. The preparation of such a document would therefore be not only essential to the gas companies, but might become of assistance to the laws of precedents.

Steps have been taken to have published and distributed to subscribers from time to time a report and digest by competent legal authority and published in much the same way as the Legal Reports and Digests now appear, *i. e.*, in bound volumes at regular periods and in small pamphlet form presenting the Commissions' rulings within a few days after they are rendered. I would ask your particular attention to this and the support of the Institute in carrying out this work, and I suggest that some action be taken by the Institute at this meeting looking to the cordial support by subscription of the publication of these volumes. In view of the large expense involved, and realizing that the value of the publications is

proportioned, almost, one might say as the Nth power of the ability of the reviewers of the decisions, it would appear that we should unite with the other public utilities interested to have this work done by the highest authority, and in the most complete way in which it can be secured.

The program that will be presented at the sectional meetings is a sufficient guarantee that in giving up your business to attend this Convention, you will be repaid by the information that can be acquired from attendance at the sectional meetings. In this connection I want to urge upon you the prompt and full attendance throughout the time that has been set aside for these sectional meetings. I am not, personally, one of those who believe that the greatest benefit can accrue in attendance at these conventions by conferences on the outside during the sessions. Important as these are, and frequently of unusual value, yet they should not be allowed to keep a member away from the sectional meetings. It is due to the men who write the papers, to the officers, and particularly to the Technical Committee, that you should be in your place promptly at the opening of each session, and that you should give full attendance to that portion of the work of the Institute which you alone can get at its full value.

VICE-PRESIDENT MCKAY (In the Chair): It is an established custom to refer the President's address to a committee, and I will designate as such a committee: Messrs. Alten S. Miller, E. G. Cowdery and J. Arnold Norcross. This Committee is scheduled to report to the Institute at the session on Friday forenoon.

(The President then resumed the chair.)

THE PRESIDENT: Next is the report of Trustees of the Gas Educational Fund. Mr. Alfred E. Forstall is unable to be present, which we regret very much, as it is unusual. I should like to call your attention to one point in this report. Curiously enough, the idea has gone abroad that the educational class of the Trustees is conducted by the American Gas Institute. That is not correct. It is an entirely separate or-

ganization, and the only connection that the American Gas Institute has with it is the fact that the Institute subscribes every year a certain sum of money, now \$500 to the work, but much the greatest portion of the expense is borne by funds provided through the Trustees.

# SIXTEENTH ANNUAL REPORT OF THE TRUSTEES GAS EDUCATIONAL FUND TO THE SUB- SCRIBERS TO THE FUND.

*To the Subscribers to the Trustees Gas Educational Fund:*

GENTLEMEN:—The Trustees appointed at the Twenty-sixth Annual Meeting of the American Gas Light Association, held October 17th, 1898, to administer the Educational Fund formed by your subscriptions, submit the following report as to the work done from October 1st, 1913, to September 30th, 1914.

The hope expressed in the last report, that practically all the subscriptions which expired during the year 1912-1913 would be renewed, has been realized and the continuance of the Practical Class for another period of 5 years has been assured.

As is shown by the report of the Secretary, the membership in the class has been maintained at the usual number.

The demand for the "Catechism of Central Station Gas Engineering in the United States" has been well sustained, 170 copies having been sold during the year. Only 179 copies still remain on hand and at the present rate of sales the edition will be exhausted within a year. As shown by the report of the Treasurer the proceeds of the sales up to September 30, 1914, have exceeded the expenses of publication and advertising by \$2,714.31, and of this amount \$2,200 has been added to the Surplus Fund.

During the year, 15 members of the Section of 1914 finished their course and their connection with the Class ceased, while the Section of 1917 started work on January 1, 1914, with a membership of 56.

The number of members in each section at the beginning of

the year, and the changes that have taken place, and the names of the members of the class who have completed the course during the year, are shown in detail on the Secretary's Report which is appended.

The Section of 1915 now contains 21 members, the Section of 1916, 18 and the Section of 1917, 63, making the total membership in the class 102.

The card index of the principal articles published in the *American Gas Light Journal*, *Gas Age* and the *Journal of Gas Lighting* has been kept up during the year.

The Treasurer's Report which is appended, shows the total amount of subscriptions to date, the available income and expenses for the year, a summary of the cash account and the statement of the amount of the surplus fund and the securities in which it has been invested.

The Surplus Fund, now amounting to \$18,977.77, is made up of a contribution of \$2,000.00, of subscriptions paid in advance of the time when they are due, of unexpended balances, of interest received on investments, and of the profit on the publication of "The Catechism of Central Station Gas Engineering in the United States."

Respectfully submitted,

TRUSTEES GAS EDUCATIONAL FUND,

WALTON CLARK, *Chairman*,

ALFRED E. FORSTALL, *Secretary*.

SECRETARY'S REPORT, SEPT. 30th, 1914.

	Section of 1914	Section of 1915	Section of 1916	Section of 1917	Total
Members enrolled Oct. 1, 1913	16	23	52		91
Entered Class Jan. 1, 1914...				56	56
Additions to Class since Jan. 1, 1914 .....				46	46
Reinstated since Oct. 1, 1913	1	5	4	2	12
	<hr/> 17	<hr/> 28	<hr/> 56	<hr/> 104	<hr/> 205

Resigned since Oct. 1, 1913..			1	5	6
Dropped for non-receipt of answers since Oct. 1, 1913	2	7	37	36	82
Finished course since Oct. 1, 1913 .....	15				15
	<u>17</u>	<u>7</u>	<u>38</u>	<u>41</u>	<u>103</u>
Total enrollment Sept. 30, 1914 .....		21	18	63	102
Applications on file for admission to class Jan. 1, 1915.....					8

NAMES OF STUDENTS WHO COMPLETED THE THREE YEARS' COURSE  
WITH SECTION OF 1914.

R. J. Bernard, New York, N. Y.	Eugene D. Milener, Jr., Baltimore, Md.
John E. Burke, Buffalo, N. Y.	
Thomas J. Byrne, New York, N. Y.	George H. Peck, Waterbury, Conn.
John H. Dyer, Providence, R. I.	Joseph Rickert, Jr., Norfolk, Va.
Donald M. Hunter, Providence, R. I.	Edward B. Ryan, Fitchburg, Mass.
C. W. Jordan, Philadelphia, Pa.	D. E. Sweet, Waterbury, Conn.
Henry R. Knowles, Philadelphia, Pa.	Wm. E. Vandell, Fitchburg, Mass.
	Raymond C. Wheeler, Collingdale, Pa.
H. S. Mason, Philadelphia, Pa.	

REPORT OF ALEXANDER C. HUMPHREYS, TREASURER, FOR THE FISCAL  
YEAR ENDING SEPT. 30th, 1914.

*Conditions of Subscriptions.*

		For year 1913-1914
Total subscriptions for third five-year period holding over .....	\$ 2,639.66	\$1,231.33
Total new subscriptions for fourth five-year period received since Sept. 30, 1913.....	17,800.00	3,550.00
	<u>\$20,439.66</u>	<u>\$4,781.33</u>
Received from subscribers since Sept. 30, 1913..	\$4,260.00	
Payments not applicable to year.....	<u>1,710.00</u>	
Total paid in by subscribers since Sept. 30, 1913, and available for year.....	\$2,550.00	
Paid in previous to current year on account of 1913-1914 installments .....	<u>2,186.33</u>	
Total paid in by subscribers available for this year	\$4,736.33	
Still to be paid for this year.....	<u>45.00</u>	
Total amount available for year.....		\$4,781.33

*Statement of Income and Expense.*

Total amount available for year.....	\$4,781.33
--------------------------------------	------------

*Expenses.*

Secretary's salary .....	\$2,750.00	
Clerical help .....	250.00	
Office rent .....	300.00	
Printing, stationery, postage, etc. ....	575.71	
Cuts used to illustrate answers.....	9.62	
Periodicals and binding .....	19.23	
	<hr/>	
Total expenses paid to Oct. 1, 1914.....	\$3,904.56	
Add for expenses incurred but unpaid..	97.63	
	<hr/>	
Total expenses for year.....		4,002.19
		<hr/>
Balance .....		\$ 779.14
Depreciation on furniture .....		11.12
		<hr/>
Total balance on year's operation...		\$ 768.02

*Cash Account.*

Received from subscribers since Sept. 30, 1913...	\$4,260.00	
Interest on securities owned as scheduled under heading "Surplus Fund" .....	885.00	
Interest on deposits in bank.....	70.14	
Received for copies of "Catechism of Central Station Gas Engineering in the United States," including carrying charges .....	776.51	
	<hr/>	
Total receipts for year.....	\$5,991.65	
Cash balance from last year.....	3,509.32	
	<hr/>	
Total to account for.....		\$9,500.97
Expenses for year paid.....	\$3,904.56	
Two bonds of the Detroit and Suburban Gas Company .....	1,777.50	
Bookcase units .....	19.00	
Expense of publication of catechism.....	7.14	
	<hr/>	
Total paid out ...		5,708.20
		<hr/>
Balance .....		\$3,792.77
Balance in Columbia Trust Co., as per Statement	\$ 528.85	
Balance in Guaranty Trust Co. of New York, as per Statement, less checks unpaid.....	3,259.48	
Cash on hand .....	4.44	
	<hr/>	
		\$3,792.77

*Publication Account.*

Total receipts to Sept. 30, 1913.....	\$5,186.89	
Received for copies of "Catechism of Central Station Gas Engineering in the United States," including carrying charges, since Sept. 30, 1913	776.51	
Total receipts to date.....	\$5,963.40	
Due for books delivered but not paid for.....	26.49	
		\$5,989.89
Total expenses to Sept. 30, 1913.....	\$3,268.44	
Expenses since Sept. 30, 1913:		
Postage and expressage .....	7.14	
Total expenses to date.....		3,275.58
Balance .....		\$2,714.31
Of this amount \$1,300 was transferred to Surplus Fund July 26, 1912, and \$900 on Jan. 8, 1914.		

*Surplus Fund and Investment.*

Amount paid in by subscribers in advance.....	\$3,078.33	
Amount paid in by subscribers to Surplus Fund..	2,000.00	
Net amount of unexpended balances previously reported .....	4,930.10	
Unexpended balance 1912-1913 .....	469.55	
Interest on bonds to date.....	5,507.22	
Interest on deposits in bank to date.....	792.57	
Transferred from Publication Account.....	2,200.00	
		\$18,977.77

*Already Invested.*

\$2,000 Binghamton Gas Works, 1st Mortgage 5% Bonds .....	\$1,930.00	
\$1,500 Atchison, Topeka & Santa Fe R. R. General Mortgage 4% Bonds.....	1,513.75	
\$2,000 Omaha Gas Co. 1st Mortgage 5% Bonds..	2,000.00	
\$1,500 New Gas Light Co. of Janesville, 1st Mortgage 5% Bonds (guaranteed by the United Gas Improvement Co.) .....	1,500.00	
\$5,000 Syracuse Light & Power Co., Collateral Trust Sinking Fund 5% Bonds.....	3,831.25	
\$2,000 Welsbach Company 5% Collateral Trust Mortgage Bonds .....	1,826.94	
\$2,000 Detroit and Suburban Gas Company, 1st Mortgage 5% Bonds .....	1,777.50	
*\$1,000 San Antonio Traction Co. 5% Bonds }	1,995.00	
*\$1,000 San Antonio Gas & Elec. Co. 5% Bonds }		
Furniture .....	100.03	
		16,474.47
Balance .....		\$2,503.30

\* These bonds were exchanged for the \$2,000 Southern Light & Traction Company 5% Bonds shown on report of Sept. 30, 1913.



NEW YORK, Oct. 7th, 1914.

The undersigned has this day examined the books and accounts of Alexander C. Humphreys, Treasurer, for the year ending September 30, 1914, and has found the same to be correct, and the above balance of \$3,792.77 to be on hand and in bank.

C. N. JELLIFFE,  
*Auditor.*

MR. WALTON FORSTALL (Philadelphia): I move that the Institute appropriate \$500 towards the Trustees Gas Educational Fund.

The motion was seconded, stated and carried.

THE PRESIDENT: We will hear the report of the Nominating Committee.

#### REPORT OF THE NOMINATING COMMITTEE.

Your Committee on Nominations begs leave to report the following:

For President:

Edward C. Jones, of San Francisco.

For First Vice-President:

Walton Forstall, of Philadelphia.

For Second Vice-President:

Sheldon J. Glass, of Milwaukee.

For Secretary-Treasurer:

George G. Ramsdell, of New York.

For Directors:

James H. Jourdan, of Brooklyn.

Charles H. Nettleton, of New Haven and Derby, Conn.

J. B. Klumpp, of Philadelphia.

James Ferrier, of Rome, Ga.

James W. Dunbar, of New Albany, Ind.

ALEX. C. HUMPHREYS, *Chairman*,  
W. B. CLINE,  
I. C. COPLEY,  
PAUL THOMPSON,  
T. R. BEAL,

*Committee.*

THE PRESIDENT: Gentlemen, you have heard the report.

CAPT. WILLIAM E. MCKAY: I move that the Secretary be instructed to cast one ballot for the election of the candidates as named.

The motion was seconded.

THE PRESIDENT: All those in favor of the motion that the Secretary be authorized to cast one ballot for the nominees, please say aye. (Ayes.) Contrary, no. (No response.) Mr. Secretary, will you cast the ballot?

THE SECRETARY: I take pleasure in casting the ballot as follows: (Reciting the names given by the Nominating Committee.)

THE PRESIDENT: You have heard the ballot. Perhaps Mr. Jones might be prevailed upon to address us. I will ask Mr. Alten S. Miller to escort Mr. Jones to the platform.

(Great applause as Mr. Miller escorts Mr. Jones to the platform.)

MR. E. C. JONES (San Francisco): Mr. President and Gentlemen of the Institute, I am deeply grateful to you for the honor you have conferred upon me this morning. It comes to me after a devotion, a loving devotion, to the gas business, of 39 years. I am deeply sensible of the high compliment you have paid to California. Besides loving the gas business and the members of the American Gas Institute particularly, I deeply love California. Next September, at our International Gas Congress, it will be necessary for the President of your Institute to have the hearty co-operation of every member of the Institute, and gentlemen, I urge you to give me your help. One man cannot do the work alone. I will devote my best energies, all that I have in me, toward the success of next year's meeting, but we must work together, and I hope that you will all come to California and help in making the meeting a glorious success. Gentlemen, I thank you. (Great applause.)

THE PRESIDENT: I have never known Mr. Jones to take as short a time to tell you of the advantages of California as

a place in which to live. (Laughter.) I am rather unprepared for it. Mr. Combs, will you conduct Mr. Walton Forstall to the platform? (Great applause as Mr. Combs (of Nashville) conducts Mr. Forstall to the platform.)

MR. WALTON FORSTALL: Mr. President and Gentlemen, I think every Chairman of a Technical Committee has always felt that it was a shame that the honor of first vice-president could not go to the whole committee instead of simply to the chairman, because every year the committee works more and more as a whole, and in behalf of the Technical Committee, I thank you for the honor. Personally, I should just like to say, following what Mr. Jones said about his interest in the gas business for 39 years, that while I have not been interested in my own person for 39 years, I remember about 31 years ago being told that my father was to deliver a presidential address in New York City to the American Gas Light Association, and ever since that time I have been more or less interested in gas association work. I am sure that I shall be very glad to do all I can to help, either in the ranks, or as an officer. I am an enthusiastic booster for the gas engineer and gas associations. I thank you very much. (Applause.)

THE PRESIDENT: Mr. Glass has sent a letter regretting his inability to be present at this meeting. Is Mr. Jourdan present? (No response.) Mr. Nettleton I know is not. Is Mr. Klumpp here? Will you come forward, Mr. Klumpp?

(Great applause as Mr. Klumpp is escorted to the platform by Mr. Percy S. Young.) You have a famous escort, I see, Mr. Klumpp.

MR. JOHN B. KLUMPP (Philadelphia): Gentlemen, I appreciate the honor, and we will try this year to make the Directors a working body. (Laughter.) I can say no more than that I thank you for the honor conferred upon me. (Applause.)

THE PRESIDENT: Is Mr. Ferrier here? (No response.) Mr. Dunbar? (No response.)

THE SECRETARY: I received a letter from Mr. Dunbar this morning; he expected to be here, but could not.

THE PRESIDENT: Gentlemen, I see that Mr. Percy S. Young, President of the Commercial Gas Association, is here. I should like to have him come forward for a moment and say a few words. (Applause, as Mr. Klumpp escorts Mr. Young to the platform.)

MR. PERCY S. YOUNG: Mr. President and Members, it is rather difficult for me to appropriately acknowledge the warm reception you have given me, but I take it as a token of your regard for your sister society. Our Association has co-operated with yours during the past year, and it has given me a great deal of pleasure to see that that has occurred. We have contributed with you towards the initial expense of the Gas Congress next year. We have joined also in contributing to prizes for designs for gas fires. Various committees of our Association have worked jointly with the committees of yours to develop work of interest to both associations. In this connection, I think it is quite timely to say that I believe the future of gas associations to be wrapped up almost entirely in the work of committees. It is not enough to have annual meetings, and then for the members to go home and neglect the work of their associations. Committee work is most important. It is very difficult to get volunteers on such work. It is impossible to draft men, but some means must be found to induce members to work on committees during the year. It gives me very great pleasure to congratulate you on the program, the excellent program, that is to be presented at this meeting, and I wish you every success. (Applause.)

THE PRESIDENT: Is President McAllister, of the Illuminating Engineering Society, in the room? (No response.) We should have been very glad to have heard from him.

The next business is the report of the Public Relations Committee. Mr. Cortelyou, will you present that report?

MR. GEO. B. CORTELYOU (New York): The Committee is

ready to report, and with your permission I will ask the Secretary, Mr. Klumpp, to read it.

Mr. John B. Klumpp then read the report as follows:

### REPORT OF THE COMMITTEE ON PUBLIC RELATIONS.

Your Committee on Public Relations for the current year beg leave to make the following report:

At the annual meeting of the American Gas Institute, held at Richmond, 1913, the Public Relations Committee when reporting on the work that had been done during that year, called attention to the importance of the action being taken by the Public Service Commissions of many states, in prescribing rules and regulations for gas service. The Committee had, up to that time, been of service in rendering assistance to gas companies and a few State Commissions in gathering and compiling data to be used in the preparation of such rules.

During the past year there has been much activity in this line and many State Commissions have called hearings for the purpose of discussing the adoption of new rules and regulations for gas service. The gas companies in these states, for the most part, have been notified of such action and have been called into general conference with the Commission and its engineers, to express their views regarding the proposed rules.

Your Committee has been appealed to, and has offered what assistance was in their power to both gas companies and Commissions, have sent one or more representatives to the several hearings referred to, and have worked in conjunction with the Public Relations Committees of several State Gas Associations.

It may be well to call attention to the following facts relating to your Committee's work in connection with Commission regulations.

On December 13, 1913, a representative of your Committee appeared, by invitation, before the Guild of Gas Managers of New England, and made a few remarks in reply to a talk

given by Mr. R. S. McBride of the Bureau of Standards, who presented to the Guild an outline of the past and proposed work of the Bureau, and defined the position of the Bureau in its work in connection with the gas industry of the United States.

On December 15, 1913, your Committee was represented at a meeting of the gas men of New Hampshire, at Manchester, and the following day at a hearing before the Public Service Commission of New Hampshire, at Concord, at which the proposed regulations for gas supply were discussed.

During the early part of 1914, your Committee prepared data and arguments that were used at a hearing before the Public Service Commission of the Commonwealth of Pennsylvania, when the rules and regulations for gas service in that State, were discussed.

In March, 1914, a paper discussing the effect of the stringent regulations of gas quality on the future economic production of gas, with special reference to the State of Indiana, was prepared at the request of the Indiana Gas Association, and presented at its annual meeting in Terre Haute. Your Committee also corresponded and conferred with many gas men of Indiana, in connection with the investigation of the quality of gas supplied by the companies of that state, and assisted in preparing a brief, protesting against some unreasonable rules adopted by the Commission.

During April, 1914, the Secretary of your Committee corresponded with the Gas Inspector of the Electrical Standard Laboratory of Ottawa, on the subject of gas testing methods in Canada.

On May 8, 1914, a representative of your committee attended a meeting of a Committee of the Ohio Gas Association in Cleveland, at which the tentative rules for gas supply issued by the Public Utilities Commission of Ohio, were discussed. Certain features included in these rules were considered as being detrimental to good service, and much data was collected

for use in presenting, to the Commission, arguments for their modification.

During May, June and July, 1914, considerable correspondence passed between the Secretaries of the Public Relations Committees of the State Gas Associations of Missouri and Illinois, and the Secretary of your Committee, in reference to rules and regulations proposed by the Public Service Commissions of those states. Comprehensive material was collected on which to base arguments to be presented to the Commissions in refuting certain objectionable features of the proposed rules.

On June 12, 1914, a representative of your Committee appeared, by invitation, at a hearing held by the Public Utilities Commission of the District of Columbia, at Washington, D. C., at which time a general discussion of the proposed rules and regulations governing the supply of gas in that city, took place.

At the request of the engineer of the Public Utilities Commission of Connecticut, your Committee submitted information and suggestions, and sent a representative to visit the laboratories of the Commission, and to render assistance in connection with the formulation of proposed rules and regulations for gas supply in that State.

The Secretary of your Committee was present with the representatives of the gas companies of the State of Maryland, at a hearing held by the Public Service Commission of Maryland, at Baltimore, September 22, 23 and 24, 1914, at which time certain features concerning the proposed regulations of the Commission, were discussed and arguments presented that would lead to the adoption of rules which would give to the citizens of that State reasonable and satisfactory service.

The Committee on Uniform Accounting, after 2 years of careful work, has finished a system of uniform accounting, which has been approved by the Board of Directors of the Institute, and is now in the hands of the Secretary of the Institute for distribution. Your Committee desires to call the

attention of the Institute to the thoroughness with which the work has been prepared. We believe that the system of accounting as submitted will be of great value to all gas companies and State regulatory bodies.

A Sub-committee of the Public Relations Committee, consisting of Messrs. W. R. Addicks, W. E. McKay, and J. B. Klumpp, was appointed to confer with the Bureau of Standards in the preparation of its Circular No. 48, entitled "Standard Methods of Gas Testing." Many members of the Institute assisted in this connection by presenting their views concerning this Circular, so that the Committee was enabled to formulate suggestions and criticisms which were presented to the Bureau. These suggestions received some consideration by the Bureau in the preparation of this Circular, which lying as it does within the definite scope of the bureau, embodies comprehensive information as to rules and methods for the testing of gas and gas service.

The same Sub-committee also received, for comment and criticism, a copy of the page-proof of the third edition of Circular No. 32, entitled "Standard Regulations for Manufactured Gas and Gas Service," and has protested against the inclusion in this third edition of statements that appear to be unwarranted, accompanying the protest with certain suggestions which were deemed worthy of serious consideration.

On April 24, 1914, a letter was sent to the *Gas World*, London, England, in reply to a letter of criticism written by Mr. Jacques Abady, concerning Circular No. 32, of the Bureau of Standards.

Your Committee has been appealed to by various members of the Institute, for information upon subjects within its jurisdiction, and has rendered all the assistance it could, and we trust these members have been thereby benefited.

G. B. CORTELYOU, *Chairman*,

S. T. BODINE,

J. L. RICHARDS,

H. L. DOHERTY,

M. W. STROUD,

E. McMILLIN,

J. B. KLUMPP, *Secretary*.



(Mr. Henry L. Doherty, a member of the Committee, was unable to sign, through absence abroad.)

THE PRESIDENT: Gentlemen, what is your pleasure regarding the report?

MR. WALTON FORSTALL: I move that it be adopted.

The motion was seconded.

THE PRESIDENT: Before putting that question to a vote, there may be some gentleman who would care to discuss this report. It appears to me that the work that has been done is the work that has been carried on by some of the busiest men, men controlling large affairs, that we have in our entire organization, and if any gentleman present cares to make any comment, the Chair would be glad to hear it.

DR. HUMPHREYS: I should like to move that the sincere acknowledgement of the obligation of this body be tendered to the Committee for the admirable work that it has done, and I think it should be no perfunctory vote of thanks. It is I believe some of the best work that has ever been done in this Institute. (Applause.)

THE PRESIDENT: Do you accept that, Mr. Forstall?

MR. WALTON FORSTALL: Yes.

CAPT. WILLIAM E. MCKAY (Boston): I second Dr. Humphrey's motion, and in doing so, refer again to the participation of this Committee in the work in New England. The report of the Committee briefly referred to the presence of their Secretary at a meeting of the Guild of Gas Managers, where, by invitation, Dr. McBride of the Bureau of Standards, was present to deliver an address, outlining the work already accomplished by the Bureau and their purpose with respect to the immediate future, and indicating in quite a definite way the extraordinary enlargement of their activities. This address of Dr. McBride, together with Mr. Klumpp's remarks, was incorporated in the *Institute News* for February, 1914. In the course of Dr. McBride's address he stated that they had received effective help through the co-operation and cordial assistance of the gas fraternity, and added that at all times

"we welcome your very frank criticism, and if we make mistakes, we want to be prompt to realize it." Mr. Klumpp began his comment by stating that he was there to hear Mr. McBride and not to criticise, but he embodied in his remarks that "the adoption of uniform methods of regulation throughout the United States seems impossible to one thoroughly acquainted with the gas business," and added some comments about the inevitable exploitation of the subject of rates, if the Bureau of Standards continued in the path that they had outlined. This meeting afforded us an opportunity of hearing from the Bureau of Standards in a very frank way just exactly what they had in their minds, and the publication of these facts in the *Institute News* enabled the matter to be brought to the attention of every member of the Institute. There are many sections of the country that will be glad to recognize at this time the serviceable assistance of the Public Relations Committee; and their service this year is more valuable than the Committee has ever before demonstrated to the Institute, and certainly forecasts a great increase in the value of the service of that Committee in each succeeding year. It may be opportune to refer again to the fact that the changes that are recommended by the Directors and incorporated in the proposed Constitution will ultimately enable the Public Relations Committee to conduct its work with even greater success.

MR. CHARLES M. COHN (Baltimore): Mr. President, I want to make grateful acknowledgment of the valuable cooperation and assistance that were given by the Public Relations Committee in Maryland to the gas companies, and to the Public Service Commission in the consideration of rules that are about to be adopted fixing standards of gas service. I understand that the Secretary of the Public Relations Committee was invited by the Chief Engineer of the Commission to give assistance to the engineering staff and the Commission in the consideration of those questions; and I am sure that Mr. Klumpp's assistance was of real benefit to all parties con-

cerned. His wide knowledge of the questions involved and his familiarity with what has been done and what is being done in other places opened up a vast fund of information. I might say, too, that Mr. Klumpp's participation at a public conference held in Baltimore was along impartial lines, and it was recognized that he was not endeavoring to represent gas companies as such, but spoke as a representative of the gas industry. It was clearly brought out that the interests of the gas companies and the public are largely identical after all. Mr. Klumpp as the spokesman of the Public Relations Committee gave very valuable assistance in Maryland.

MR. WALTER F. NORTON (Nashua, N. H.): I wish, on behalf of the New Hampshire gas companies, to thank the Association for the good work it did for us in our State through Mr. Klumpp, Secretary. Without his great knowledge, I do not know where we would have landed. I feel we must thank the Institute for the great help it rendered by sending him to New Hampshire. (Applause.)

MR. WILLIAM O. LAMSON (West Chester, Pa.): On behalf of the Pennsylvania Gas Association, I want to say that Mr. Klumpp and his Committee did invaluable work for us. The Commission in our State was new; it wanted information; it wanted help. (Applause.)

MR. H. L. RICE (Aurora, Ill.): I am very glad to note that particular attention is being directed to the work of the Committee in co-operation with the various State Associations. It should be so directed, because it seems that no more valuable work has ever been done in the history of this Institute. In Illinois we were confronted this year with the project of rules and regulations by a new State Commission. Our Public Relations Committee appealed to the Public Relations Committee of the Institute for assistance, and on behalf of the State Gas Association of Illinois, I wish to acknowledge the valuable assistance we received, and the great benefit to us in obtaining from the Commission reasonable rules, which you have no doubt seen recently published, and which are con-

siderably in line with other fair regulations throughout the country. I feel that we were greatly benefitted by this assistance and we feel very grateful. (Applause.)

MR. J. ARNOLD NORCROSS (New Haven, Conn.): Mr. President, I am glad to have an opportunity to express my appreciation of the work of this Committee during the past year.

The report we have just heard is all too modest and gives little idea of the magnitude of its work or of the importance of the results accomplished.

During the year an unusual number of states have been framing rules and regulations for gas service, and our Committee has taken an active part in this difficult work of settling the terms under which gas companies shall do business. Through their most efficient and able Secretary, Mr. John B. Klumpp, they have placed their service and an almost inexhaustible fund of information and data at the disposal of both companies and commissions. Through these efforts the regulations adopted are, in the main, practical and reasonable. While perhaps not entirely to our satisfaction, it is certain that without the work of the Committee the rules adopted would have been in many respects neither practical, nor reasonable.

In Connecticut, the Utilities Commission is just now working up rules for gas service. Before the gas companies were aware of this fact, Mr. Klumpp had already been in touch with the situation, and furnished to the Commission a large amount of information which can but be helpful to both sides involved. He has since furnished much needed and valuable advice and data to the gas men themselves. Such work substitutes co-operation for controversy and can but tend towards a mutually satisfactory outcome.

Speaking for the gas managers of Connecticut, I would express deep gratitude and appreciation to the Public Relations Committee in general, and to its Secretary in particular, for the help it has given us.

But there is another point of view—this good work has been

carried on all over the country. Whatever is accomplished in one quarter assists greatly in every other. One of the ablest men in the Institute has given up a large share of his time to it. He has traveled to the four points of the compass for the Committee on Public Relations. The benefits have been widespread and marked, both to the public and the industry. All interested have enjoyed the fruits of his labor. In my judgment, it is the most important work the Institute can do and should by all means be continued.

THE PRESIDENT: Gentlemen, the motion is before you. Are you ready for the question? (No response.) All those in favor will please say aye. (Ayes.) Contrary, no. (No response.) It is so ordered.

Next is the report of the Technical Committee, Mr. Walton Forstall, Chairman.

## REPORT OF THE TECHNICAL COMMITTEE.

### ORGANIZATION.

The Technical Committee is the agent through which the Institute plans its meeting programs and decides on lines of work, and, under the Board of Directors, is the spokesman of the Institute on all matters not involving the Public Relations Committee. To be thoroughly qualified for its work, it should be composed of representatives from the various phases of the gas industry. Also, these men should be drawn from different sections of the country, in so far as such geographical selection is compatible with attendance at committee meetings, which of necessity are held at Institute headquarters.

The Technical Committee has before it at all times the same problem that confronts similar committees in other societies, and that is to discover and enlist the men who are able and willing to work in the ever widening field in which the Institute can benefit the public, the industry and the individual worker. Certain subjects naturally suggest the names of well known men, who have made a name in the past for the thoroughness of their association work. Most of these men, however, have earned at least a comparative rest, and yet if

some did not still shoulder a good part of the burden, both the quality and quantity of the Institute's achievements would be materially less.

This year, in order to interest directly a number of men in the various section programs, program sub-committees were formed, the chairman being a member of the Technical Committee, and the other members, men interested in that particular branch. The experiment has not succeeded as well as was hoped, but the principle on which it was based is a correct one, and if the younger members of the profession would only realize their duty to the industry and to themselves, not to hide their particular ability and willingness, next year's committee would be at a great advantage in choosing its co-workers.

#### MEETINGS.

The wise practice of holding monthly meetings, initiated by last year's committee was again followed this year, and nine meetings were held, the minutes of which have appeared in the Institute News. Two years' experience has proved the value of these frequent meetings, and they should become a permanent feature of the committee's work.

#### WORK.

The result of this year's work is before you in the program for the New York meeting, your approval of which is now asked.

The program was originally planned for four sections—manufacturing, chemical, distribution and accounting. In April, the Directors authorized an illumination section. The success attendant on convening in five sections will not be known until after the meeting, but if the new sections are not properly supported by those who should be interested in their topics, it may be considered settled that, at least for the present, the Institute is not willing to cover the whole field of the gas industry, being content to restrict its activities to engineering lines. Whether success or failure results, the experiment should have been made in 1907, and not delayed until 1914.

### RECOMMENDATIONS.

As is probably true of other trade associations, the Institute has suffered from the lack of continuity in organization incident to annual changes in officers and committees. To place this year's experience as far as may be at the disposal of the next Technical Committee, the following recommendations are made:

Immediately upon its formation, the Technical Committee should ask each affiliated association in what way it would like to assist the Institute, and what present or past work it had done which in its opinion should be called to the attention of the Institute members.

Where subjects under investigation by the Institute are still worthy of consideration, committees should be re-appointed with the same members or with such changes as past experiences or new conditions would indicate. At least two or three times during the year, these committees should be asked to make progress reports to the Technical Committee.

The subjects suggested for attention next year are:

#### Manufacturing:

- (1) Carbonization.
- (2) Refractory Materials.

#### Chemical:

- (3) Chemical Tests.
- (4) Physical Tests.

#### Distribution:

- (5) Pipe Joints.
- (6) Pipe Standards.
- (7) Meter Connections.
- (8) Housepiping.
- (9) Standardization of Lamps and Mantles.
- (10) Utilization of Gas Appliances.

#### Accounting:

- (11) Rates.
- (12) Uniform Accounts.

#### General:

- (13) Accident Prevention.

The first three and last four numbers are now under investigation. "Physical Tests" is necessary in order that we may at least attempt to standardize our methods of making and reporting performance tests. "Pipe Joints" is a subject on which little is *known* and where much that is done is based upon tradition. As street main work requires millions of dollars annually, the question merits all the brains the Institute can command. "Pipe Standards" needs a committee for some years longer at any rate, to facilitate the adoption of the new standards. "Meter Connections" deserve consideration and are probably capable of a certain amount of standardization which would prove of benefit both to the user and the maker of these connections. "Housepiping" has received no association attention since 1898, and the "Table for Housepiping" then adopted by the American Gas Light Association is probably unknown to most gas companies. There is no more important subject connected with the struggle to retain our share of the lighting field, than this one of housepiping, for housepiping defects are potent contributors to unsatisfactory lighting. Closely related is proper fixture design, and this should be cared for by the Committee on Housepiping, unless the Committee on Utilization of Gas Appliances can devote more time to it than the pressure of its fuel appliance work has allowed it to do in the past. "Standardization of Lamps and Mantles" is referred to in the Report of the Committee on Utilization of Gas Appliances, and there is plenty of evidence that the retention of the illumination field is made more difficult by the many inferior lighting appliances now available to the user of gas.

WALTON FORSTALL, *Chairman*,  
W. S. BLAUVELT,  
C. N. JELLIFFE,  
C. E. REINICKER,  
R. E. SLADE,  
H. L. UNDERHILL.



THE PRESIDENT: Gentlemen, what is your pleasure regarding the report of the Technical Committee?

CAPT. WILLIAM E. MCKAY: I move that the report of the Technical Committee be accepted and that the Secretary be instructed to direct the attention of the incoming Technical Committee to these recommendations. Also that the vote carry with it the appreciative thanks of the Institute for the excellent work of this Committee.

The motion prevailed.

#### REPORT OF THE COMMITTEE ON BEAL MEDAL.

THE PRESIDENT: Gentlemen, the next business is the report of the Committee on the award of the Beal Medal, Mr. W. Cullen Morris, Chairman.

MR. W. CULLEN MORRIS (New York): I regret Mr. President I am unable to report that the Beal Medal Committee has made an award. I will endeavor to make a report before this session to-day, or on Friday.

The President then called on the Chairman of the Committee on Arrangements to report.

#### REPORT OF THE COMMITTEE ON ARRANGEMENTS.

MR. C. D. ROBISON (New York): The Chairman of the various sub-committees of the Committee on Arrangements has asked me to make a few announcements. The attention of the members is called to the announcement boards. There will be one of these in each of the meeting rooms, showing coincidentally what is being carried on in the various meetings. On the program the papers are designated by numbers, and as a paper is about to be discussed in any of the rooms, the number of that paper, with abbreviated title, and the name of the author will appear on the announcement board in each of the other rooms, which will permit members interested in a paper about to be discussed in another section to leave the section in which they are at that time and go to the room in which the paper they desire to hear is being discussed.

THE PRESIDENT: The program that has been made out by the very efficient Committee on Arrangements I think is one that will meet with your approval throughout, and I personally feel very much indebted to these gentlemen for the unremitting efforts that they have made to make this Convention a success in every particular.

MR. W. R. ADDICKS (New York): Mr. President and Members, I desire Mr. Cortelyou, President of the Consolidated Gas Company, to extend to the members of the Institute, an invitation, in addition to that referred to in connection with the trip mentioned by Mr. Robison, to visit the general office building at Fifteenth Street and Irving Place. The Fourteenth Street subway express stop is the nearest point by subway, and either the Broadway car or the Forty-second Street car, with transfer on Third Avenue, are convenient for reaching the general office building. The restaurant on the nineteenth floor, the very complete gas kitchen, as well as the complete electric kitchen, will interest all of you. The display of appliances both on the main floor and in the basement will interest you, and our many facilities with respect to lighting gas will also engage your attention, the entire building being piped for gas from top to bottom, but also being provided with electric facilities. We trust the members will avail themselves of this at their convenience. I would like to say that the building will be illuminated to-night. (Applause.)

## REPORT OF THE COMMITTEE ON REVISION OF CONSTITUTION.

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**This Constitution to go into effect September 1, 1915.**

# CONSTITUTION AND BY-LAWS OF THE AMERICAN GAS INSTITUTE

## CONSTITUTION

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### NAME.

SECTION 1. The name of this Association shall be the American Gas Institute.

### OBJECTS.

SECTION 2. The objects of this Institute is to amalgamate into one body the American Gas Light Association, the Ohio Gas Light Association, and the Western Gas Association and to facilitate co-operation between the various state and district associations that now exist, or may hereafter be formed within the territory covered, and to secure thereby the more rapid promotion and advancement of scientific and practical knowledge in all matters relating to the construction and management of gas works and the manufacture, distribution and consumption of gas; the firmer establishment and maintenance of a spirit of fraternity between those interested in the gas business by affording opportunity for social intercourse and friendly interchange of information and ideas; the inducement and extension of more cordial and friendly relations between gas companies and consumers of gas based upon their mutual interests, and the education of employees of gas companies to enable them to better perform their

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duties. Also to take over such property and assets of the associations named as may be legally invested in the Institute.

## MEMBERS.

SECTION 3. The membership of the Institute shall consist of Honorary Members, Active Members, Junior Members and Associate Members. Honorary Members, Junior Members and Associate Members shall not be entitled to vote except in Section meetings as provided in Section 39 hereof, nor to hold office, but shall be entitled to all the other privileges of membership.

SECTION 4. Honorary Members shall be persons whose scientific or practical knowledge in matters relating to the gas industry, and whose efforts and interests in that behalf shall recommend them to the Institute.

SECTION 5. To be eligible to Active Membership, a person must be at least 26 years of age, and be an officer or other employee of a gas company; (or a Consulting Gas Engineer, or an employee of a Consulting Gas Engineer) *or a consulting expert in some branch of the gas industry*. He must be competent to act efficiently as the Manager of a department of a Gas Company's business and must have his chief interest in the gas business directly connected with the manufacture, sale, or utilization of gas, and not the manufacture or sale of apparatus or appliances used by Gas Companies.

SECTION 6. To be eligible as a Junior Member, a person must be over 20 years of age and be in the employ of a Gas Company, or (of a Consulting Gas Engineer) *of a consulting expert in some branch of the gas industry*, and must be qualified either by experience or education to hold a responsible position under such employers.

SECTION 7. To be eligible as an Associate Member, a person must be engaged in a pursuit which constitutes a branch

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of *the* gas (engineering) *industry*, or be otherwise qualified to assist in promoting the objects of the Institute.

SECTION 8. Charter Members shall be such of the present membership of the American, Ohio, or Western Gas Association as shall be certified by the officers of the same to the Directors of the Institute as qualified respectively for Active, Junior or Associate Membership, provided that to become a Charter Member, it shall be necessary for each person so certified to make application to the Directors of the Institute within a period of sixty days after notice has been sent him of the formation of the Institute.

#### ELECTION OF NEW MEMBERS.

SECTION 9. (Honorary Members shall be proposed by the Directors to the members of the Institute by mailed notification immediately after any annual meeting, and shall be voted upon by letter ballot at the time of the regular September ballot next following.) *Candidates for Honorary Membership, if endorsed by not less than ten members of the Institute, in writing to the Board of Directors, shall be voted upon by the Board and if receiving the unanimous vote of the Directors voting, shall be voted upon by the voting membership of the Institute not less than one year thereafter by a special mail ballot.*

SECTION 10. Every application for either Active, Junior or Associate Membership shall be made to the Secretary in writing upon a form approved by the Directors, upon which shall be set forth as the grounds of the application a complete account of the qualifications and experience of the applicant and his agreement to conform, if elected, to the Constitution, By-Laws and Rules of the Institute (and shall be endorsed by at least two Active Members to whom the applicant is personally known. The Secretary shall submit each application to the Directors, who shall consider and act upon

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it and assign the applicant to the grade of membership to which, in their judgment, his qualifications entitle him. The name of each candidate thus approved by the Directors shall, unless objection is made by the applicant, be submitted to the voting membership for election by means of a letter ballot.) *Each applicant must be endorsed by at least two Active members to whom he is personally known. The Secretary shall submit each application to the Membership Committee, who shall consider and act upon it and assign the applicant to the grade of membership to which, in their judgment, his qualifications entitle him. The name of each candidate thus approved by the Membership Committee, unless objection is made by the applicant, shall, after approval by the Directors, be submitted to the voting membership for election by means of a letter ballot.*

SECTION 11. It shall be competent for any Junior or Associate Member to apply for transfer to another grade of membership. The application for such transfer shall be made in the same manner as in the case of a new applicant.

SECTION 12. Election to membership shall be by a sealed letter ballot as the By-Laws shall provide. Adverse votes to the number of 2 per cent. of the votes cast shall (be required to) defeat the election of an applicant for any grade of membership. The Directors may, in their discretion, order a second ballot upon a defeated applicant, in which case adverse votes to the number of 4 per cent. of the votes cast shall be required to defeat the election.

SECTION 13. Any person elected to the Institute, except Honorary Members, must subscribe to the Constitution and pay to the treasurer the initiation fee and one year's dues for his grade of membership before he can be entitled to the rights and privileges, or can receive a certificate of membership. If this requirement is not complied with within six

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months of the notification of the election the applicant shall be deemed to have declined the election and the election shall be void.

### INITIATION FEES AND DUES.

SECTION 14. The initiation fee for membership in each grade shall be as follows:

For Active Members.....	(\$15.00)	<i>\$10.00</i>
For Associate Members.....	( 15.00)	<i>10.00</i>
For Junior Members.....	( 5.00)	<i>5.00</i>

The initiation fees shall not include the dues for the current year in which the applicant is elected.

SECTION 15. A Junior Member, on promotion to any other grade of membership, shall pay an additional fee of (\$10.00) \$5.00, except that Charter Junior Members shall not be required to pay such additional fee. No person shall retain Junior Membership for more than two years after becoming qualified for Active Membership.

SECTION 16. The annual dues, payable in advance, for membership in each grade shall be as follows:

For Active Members.....	(\$10.00)	<i>\$15.00</i>
For Associate Members....	( 10.00)	<i>15.00</i>
For Junior Members.....	( 5.00)	<i>7.50</i>

SECTION 17. The Directors may in their discretion permit any Active or Associate Member to become a Life Member in the same grade by the payment in one sum of an amount sufficient to purchase from a reputable life insurance company an annuity on the life of a person of the age of the applicant equal to the annual dues in his grade of membership. Such life member shall not be liable thereafter for annual dues. (Life Members of the associations dissolving shall only be required to pay the difference, if any, between the sum computed as above and that already paid for their present Life Membership.)

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SECTION 18. The Directors shall have power by letter ballot to admit to Life Membership, without payment of a Life Membership fee, any person who for a long term of years has been an Active or an Associate Member, when, for special reasons, such an action would, in their judgment, promote the best interests of the Institute. Notice that such action as proposed shall have been given at a previous meeting of the Directors and one dissenting vote shall defeat the proposed action.

#### SUSPENSIONS AND EXPULSIONS.

SECTION 19. *Any member may retire from membership by giving written notice to that effect to the Secretary, and paying all dues to date, unless released from said payment by a vote of the Directors.* A member whose dues for a year completely expired are not paid, shall not be entitled to vote, nor to participate in the deliberations of the Institute, nor to receive a copy of the PROCEEDINGS. Any member whose dues shall remain unpaid for a term of three years may be dropped from the roll of membership by a vote of the Directors. A member dropped for non-payment of dues may upon paying the amount he owes the Institute, be reinstated at the option of the Directors.

SECTION 20. The Directors may refuse to receive the dues of any member of any grade who shall have been adjudged by them to have violated the Constitution or By-Laws of the Institute, or who, in their opinion, shall have been guilty of conduct rendering him unfit to continue in its membership, and such person may be expelled from the Institute (upon a recommendation to that effect made) *after notice and hearing* by the Directors (at any general meeting of the Institute) *upon unanimous vote of the Directors present.* (The vote upon expulsion shall be by ballot and shall require two-thirds of the votes cast for its adoption.)



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SECTION 21. The Directors may transfer any member from his then present to any lower grade of membership. They may also refuse to receive the dues of any member who is no longer eligible to any grade. No transfer of grade shall be made, or refusal to accept dues recorded, except upon notice from the Secretary, whose duty it shall be to give such notice, that said member is no longer eligible for membership in his then present grade, and that said member has for a period of ninety days after notification of such non-eligibility, failed to apply for transfer. The vote in each case shall be by ballot, and shall require two-thirds of the votes cast for its adoption.

## MANAGEMENT.

SECTION 22. The affairs of the Institute shall be managed by the Directors, subject to the control of the general meeting.

SECTION 23. The Board of Directors shall consist of the President, the Vice-Presidents, the Secretary, the Treasurer, the Junior Past-President, and until changed as hereinafter provided for, ten Active Members of the Institute. Five members *elected by the Institute* shall constitute a quorum for the transaction of business. If arrangements are made for co-operation between the Institute and district and state gas associations, as hereinafter provided for, the number of members of the Board elected from the Active Members of the Institute shall be increased from time to time, as it becomes necessary, in order to keep the number of Directors elected by the Institute equal to not less than two-thirds of the total number of both Institute and Associate Directors.

SECTION 24. Should a vacancy occur in the Board of Directors or in any elective office, except the Presidency or First Vice-Presidency, through death, resignation or other cause, the Directors may elect an Active Member to fill the vacancy until the next annual election.

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SECTION 25. The Directors shall regulate their own proceedings, and may, by resolution, delegate specific powers to an Executive Committee, or to any one or more of their members. No act of the Executive Committee, or of a delegate shall be binding until it has been approved by a resolution of the Directors.

SECTION 26. The Board of Directors shall present at the annual meeting of the Institute a report verified by the President, Secretary and Treasurer, or by a majority of the members, which shall show the state of the finances of the Institute at the date of the report; the receipts and expenditures for the fiscal year immediately preceding; the names and places of residence of the persons who have been admitted to membership in the Institute during that year, and give an account of the action taken by the Directors upon matters coming before it and recommendations as to the action to be taken by the Institute. This report shall be filed with the records of the Institute and an abstract of it shall be entered in the minutes of the proceedings of the annual meeting.

#### OFFICERS.

SECTION 27. At each annual meeting there shall be elected from among the Active Members a President, *a Vice-President for each Section into which the Institute is at the time divided*, (two Vice-Presidents) a Secretary, a Treasurer, and until otherwise provided for, five members of the Board of Directors. All of the officers shall be elected for one year, but the members of the Board of Directors shall be elected for two years. (At the first general meeting ten members of the Board of Directors shall be elected, five to hold office for one year and five to hold office for two years.)

SECTION 28. All elections shall be by ballot.

SECTION 29. The term of all elected officers shall begin on the adjournment of the annual meeting of the Institute at

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which they were elected. Officers shall continue in their respective offices until their successors have been elected and have accepted such election.

SECTION 30. The President and the retiring Active Members of the Board of Directors shall not be eligible for re-election the following year.

SECTION 31. Previous to each annual meeting it shall be the duty of the Directors to appoint a nominating committee of five members, none of whom shall be a Director. It will be the duty of this nominating committee to present at the annual meeting a list of the Active Members and Directors whom they recommend as officers for the ensuing year. *It must select the Vice-President for each section from three active members to be chosen by a majority vote of that Section at the preceding annual meeting.*

SECTION 32. Twenty or more members entitled to vote may constitute themselves a special nominating committee with the same powers as the nominating committee appointed by the Directors.

SECTION 33. The Directors shall appoint from their own number immediately after the meeting at which they are elected a finance committee of three members.

SECTION 34. The President shall take the chair at all meetings of the Institute *wherever the members meet as one body* and of the Board of Directors (and of the committees at which he is present). *He shall be an ex-officio member of every committee and sub-committee.* He shall determine to which general committee any matter shall be referred.

SECTION 35. In the absence of the President one of the Vice-Presidents shall take the chair; *if more than one Vice-President be present in the absence of the President, the Vice-President to preside shall be determined by lot,* and in the absence of the President and Vice-Presidents a Chairman

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shall be appointed by the Directors from among their own members. *Each Vice-President shall be the presiding officer of the section for which he was designated on nomination. He shall be ex-officio member of each committee relating solely to the work of his section.*

SECTION 36. The duties of the Secretary shall be to take minutes of all proceedings of the Institute and of the Board of Directors and to enter them in proper books for that purpose. He shall conduct the correspondence of the Institute, read minutes and notices of all the meetings, and also such papers and communications as are considered in the absence of their authors, and perform whatever other duties may be required in the Constitution and By-Laws appertaining to this department. *There shall also be a Secretary for each Section to be appointed by the Chairman of the Section, and with the same term of office. His duties shall be in general to assist in conducting the meetings of his Section.*

SECTION 37. The duties of the Treasurer shall be to receive and keep all annual dues and funds of the Institute, to keep correct accounts of same, and pay all bills approved by the President and a member of the Finance Committee, and he shall make an annual report to be submitted to the Institute.

SECTION 38. The duties of the Finance Committee shall be to audit the books, accounts and statements of the Treasurer; to invest the funds of the Institute, and to care generally for the finances of the Institute, subject to the control of the Directors.

SECTION 39. The duties of the Directors shall be to have the general management of the affairs of the Institute, and to prepare for its meetings. No paper or report that has not had the approval of the Directors shall be read at any meeting *of the Institute or any Section thereof.*

The Directors shall have the power to appoint, from time

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to time, a Committee on Arrangements from among the members to assist the Board of Directors in arranging for the meetings of the Institute. The Directors shall have power to fill for the unexpired term, any vacancies occurring by death, or resignation, in their own number, or in the general committees. *The Directors shall have power to provide for the voluntary division of the membership into two or more sections for the choice of sectional Vice-Presidents and for the hearing and discussion of papers and reports. The functions and powers of such sections shall be limited to the nomination of a Vice-President, the providing and consideration of papers and reports, the reference to committees and to recommendations to the Institute or the Board of Directors. Any member of the Institute may attend the meeting of any section at any time. Any Active or Associate Member may vote on section matters in one section only, and to so vote must register as a voting member of such section. He may change this registration on one year's notice to the Secretary of the Institute.*

*Upon the written application to the Directors of any thirty members of the Institute asking for the creation of a new section the Directors shall proceed to form the section applied for.*

Any resolution, report or recommendation, that has not been considered and approved by the Directors, and that in the opinion of the Chair would have the effect of changing the policy of the Institute, or committing it to any new policy or opinion to which it had not theretofore been committed, should be referred, before adoption, to the Board of Directors, whose duty it shall be to report to the next regular meeting of the Institute upon such committal, if any, and its proper phrasing.

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SECTION 40. There shall be two general committees, each reporting to the Board of Directors and responsible to the Board for such part of the work of the Institute as is delegated to it in accordance with the provisions of Sections 34, 41 and 42. Each committee shall be composed of *at least* six members, (to be) appointed each year by the President-elect, and (to) serve one year.

SECTION 41. One general committee shall be called the Public Relations Committee, and to it shall be referred all investigations, reports, recommendations, resolutions and matters of any kind affecting the relations between the Institute, or its members, and the public, or any governing bodies, except as herein provided.

SECTION 42. One general committee shall be called the Technical Committee, and to it shall be referred all investigations, reports, recommendations, resolutions and matters of any kind having to do with the construction, operation and extension of gas works, and the conduct of the affairs of gas companies, not specifically delegated to the Public Relations Committee by Section 41, and except as herein otherwise provided. *Each section shall have a representative on this Committee.*

SECTION 43. Each general committee shall have the power to appoint sub-committees. (Each) *Any* sub-committee (shall consist of one member of the general committee, the other members being taken) *may be appointed* from the general membership of the Institute, and shall exist at the pleasure of the general committee by which it was appointed, and to which its report shall be made.

#### MEETINGS AND PROCEEDINGS.

SECTION 44. The annual meeting of the Institute shall be held on the third Wednesday of October of each year, at such

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place as shall be designated by the Institute at the previous meeting. In case of emergency the Directors shall have the power to change the time or place of meeting, or both, as so designated, by a three-fourths vote of all its members, at the call of the President, and such vote may be taken by mail.

SECTION 45. The Secretary shall send notices to all members of the Institute at least fourteen days before each general meeting, mentioning the papers to be read and any special business to be brought before the meeting. *During a recess in any meeting of the Institute, taken in order that section meetings may occur, no meeting of the Institute other than as provided at the time the recess is ordered shall be held until one hour after a call for such meeting has been read in each section meeting at the time in session, and has been posted on the official bulletin board. The President shall have the authority to issue such call, and it shall be obligatory on him to issue such call on the written request of fifty members.*

SECTION 46. Special meetings of the Institute may be called at the option of the Directors, and the Secretary shall call a special meeting on the written request of one hundred members.

The notices for special meetings shall be sent to all members at least three weeks before the date for which the meeting is called and shall state the business to be transacted, and no other shall be entertained.

SECTION 47. Thirteen members shall constitute a quorum.

SECTION 48. All questions, except as otherwise provided in Sections 9, 20, 28, 49 and 57, shall be decided by any convenient system of open voting, the presiding officer to have a second or casting vote when necessary.

SECTION 49. Questions of a personal nature shall be decided by ballot and all parliamentary procedure not specifically covered by this Constitution shall be governed in accordance with Roberts' Rules of Order.

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SECTION 50. Any member, with the concurrence of the presiding officer, may admit a friend to each meeting of the Institute, but such person shall not take part in any of the discussions unless permission to do so be given by the meeting.

SECTION 51. All papers read at the meetings of the Institute must relate to matters, either directly or indirectly connected with the objects of the Institute, and must be approved by the Directors before being read.

SECTION 52. All papers, drawings or models submitted to the meetings of the Institute shall be and remain the property of the authors.

SECTION 53. The President, the Junior Past-President, the First Vice-President, the Junior Past-Chairmen of the two general committees, and the Secretary shall constitute a Publication Committee, and nothing shall be included in the published reports of the Institute's PROCEEDINGS, or in any other publication issued by its authority, that has not been approved by at least two-thirds of the full membership of the Publication Committee.

SECTION 54. The Directors shall meet the day before each general meeting of the Institute, and also on such day between June 1st and September 15th, both inclusive, as may be designated by the President by notice given at least one week in advance of meeting. Special meetings may be called when the President shall deem it necessary, and the President shall be required to call a special meeting at any time on the written request of five members of the Board. Of such meetings reasonable notice shall be given by special call, in print or writing, specifying the business to be attended to.

## GEOGRAPHIC AND DISTRICT SECTIONS.

SECTION 55. A. (In so far as the district associations now affiliated with the Institute carry out their agreements not to



All matter shown between parentheses to be dropped;  
all matter in italic to be inserted.

elect to voting membership any person connected in any way with the gas industry who is not directly identified with gas or electric interests within the state or district designated by the name of the association; and to consult with the Institute before undertaking any original work of interest to the gas profession, such associations will continue in affiliation with the Institute, but no further arrangements will be made for affiliation with any other association. Each and every district, or state gas, or gas and electric association, with which such agreements have been entered into, shall be entitled to elect one of its members a member of the Board of Directors of the Institute. The members so elected will be in addition to those named in Section 23, provided that the number of such associated directors shall never exceed one-third of the total membership of the Board. Should the Board of Directors provide for an executive committee, this committee shall include in its membership one man from each of the affiliated associations as long as the number of such associations does not exceed six. Thereafter there shall be on the executive committee at least six men who are members of affiliated associations and have among them membership in at least six such associations.) *The Board of Directors may in its discretion make with any gas, electric, or gas and electric association an affiliation agreement upon such terms as may be mutually agreed upon, provided the membership or objects or interest of such association are not in conflict with those of the Institute. An affiliation agreement shall provide for the termination of such agreement on twelve months notice by either party.*

*An affiliation agreement may provide for representation of the affiliated association on the Board of Directors of the Institute; but in such case said association shall at no time have more than 20 per cent. of its voting membership persons not*

All matter shown between parentheses to be dropped;  
all matter in italic to be inserted.

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*directly identified with gas or electric interests within the state or district designated by the name of the association; and said association shall agree to present (on the request of the Directors of the Institute) the result of work of interest in the form of a report to the Board of Directors of the Institute; such affiliated Associate Directors shall be additional to the Institute Directors provided for in Section 23, and shall at no time exceed one-third of the total.*

B. The Board of Directors may in its discretion authorize the formation of geographic sections. The territory to be included in each section shall consist of a state, or group of states.

C. Subject to the approval of the Board of Directors of the Institute and the governing body of the geographic section in which it is located, city or district sections may be formed.

D. The geographic and city or district sections may adopt such constitutions and By-Laws and elect such officers as they see fit, provided that nothing shall be done in violation of the Constitution and By-Laws of the American Gas Institute.

E. After giving due notice, any section may send a representative to appear before the Board of Directors of the Institute for the purpose of conferring with the Board in regard to any matters relating to the affairs of the Institute in the territory embraced by the section.

F. The Secretary of the section shall report its proceedings to the Secretary of the Institute.

G. No person shall be eligible for membership in any section who is not a member of the American Gas Institute.

H. Sections may be dissolved for failure to comply with the Constitution and By-Laws of the Institute.

#### PROCEEDINGS.

SECTION 56. Each member of the Institute in good standing shall be entitled to and shall be furnished by the Secretary

All matter shown between parentheses to be dropped;  
all matter in italic to be inserted.

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with a copy of the PROCEEDINGS of the Institute for the current year, in which shall be listed the names and addresses of the members. In any such list each member should be listed by the title, or titles, only, from which he derives his eligibility to his class of membership.

### AMENDMENTS.

SECTION 57. All propositions for adding to or altering any of the provisions of the foregoing Constitution shall be laid before the Directors, who, if they see fit, may bring it before the next general meeting of the Institute, and who shall be bound to do so on the requisition in writing of any ten members of the Institute. All such propositions shall be decided by ballot and shall require two-thirds of the vote cast for their adoption.

W. R. ADDICKS, *Chairman*,  
I. C. COPLEY,  
WALTON CLARK,  
A. E. FORSTALL,  
W. E. MCKAY,  
S. J. GLASS,  
A. S. MILLER,  
W. H. GARTLEY, *Ex-officio*.  
GEO. G. RAMSDALL, *Ex-officio*.

THE PRESIDENT: Now, gentlemen, we come to a vote on the subject of the proposed revision of the Constitution. Are you ready to take action?

MR. WALTON FORSTALL: I move that the Secretary be instructed to cast the ballot of the Institute for adoption of the report of the Committee on Revision of the Constitution.

The motion was seconded.

THE PRESIDENT: You have heard the motion, gentlemen.

All those in favor, please say aye. (Ayes) Contrary, no. (No response) Mr. Secretary, you are authorized to cast the ballot.

THE SECRETARY: Mr. President, I cast the unanimous ballot of the Institute for the Constitution as revised by the Committee appointed for the purpose. Those that were not here when the Directors' report was read will notice that the By-Laws have not yet been revised and could not be until the Constitution was adopted, but it was recommended at the meeting of the Directors yesterday that if this is adopted at this time, a Committee be appointed to revise the By-Laws.

THE PRESIDENT: Following out the provisions of the Constitution as just adopted, it will be incumbent on each one of the Sections to nominate three members, whose names will be presented to the next Nominating Committee, and from whom will be selected the vice-presidents to represent that Section. Each Section will have one vice-president, and the number of the vice-presidents during the coming year will be determined by the number of the Sections.

THE PRESIDENT: The Secretary makes the suggestion that we should have enough copies of the new Constitution printed to be sent to all the members. We recommend that to the next Board of Directors.

The President then called on Mr. Paul Doty for the following report:

#### REPORT OF THE COMMITTEE ON CLASSIFICATION OF AWARDS, PANAMA-PACIFIC INTER- NATIONAL EXPOSITION.

The Committee on Classification of Awards of the Panama-Pacific International Exposition was appointed by the American Gas Institute to secure appropriate recognition of the magnitude and importance of the gas industry from the Exposition authorities, in the official classification of exhibit departments. This has been accomplished. Your Committee attaches hereto a copy of the Official Classification of Exhibit

Departments of the Universal Exposition of 1915 as finally amended, and approved by the President of the Panama-Pacific International Exposition under date of February, 1914. Exhibits for the manufacture, distribution and uses of gas are primarily included in Group 70, Department E,—Manufacturers and Varied Industries. (See Report of the Committee 1913, PROCEEDINGS, p. 58.) The classification recommended by your Committee and approved by their Directors, has been submitted to Mr. Chas. H. Green, Chief of the Department of Manufactures and Varied Industries, and to Captain Baker of the Panama-Pacific International Exposition and Captain Baker has assured us that our classification will be submitted to the International Jury of Awards to cover their work.

The Official Classification attached hereto is not intended for publication in your PROCEEDINGS,—it is too extensive, and covers a multitude of exhibits of all classes—it is submitted so that your officers may have a ready reference for intending exhibitors in the gas industry.

Following is a list of the more prominent possible exhibits allied with the gas industry, and reference is made to their respective class exhibits for awards.

Exhibit	Official classification index
Accidents, Appliances for use in.....	144, 145
Acetylene .....	357
Ammonia Liquor Concentrators .....	353
Benches, Coal Gas, Iron Work.....	353
Benches, Coal Gas .....	353, 782
Blowers for Gas Appliances.....	355
Burner, Gas .....	355
By-Product Gas Ovens .....	353
Calorimeters .....	125
Coal, Gas .....	776
Coal and Coke Handling Machinery.....	450
Coal Gas Manufacture .....	353
Coke .....	776
Combustion Recorders .....	455
Compressors, Gas .....	464
Condensers, Gas .....	353

	Official classification index
Domestic Appliances, Gas .....	355
Engines, Gas—Turbines, Gas .....	456
Exhausters and Blowers .....	354
Fire Brick and Blocks.....	767
Fixtures, Gas .....	355, 358
Furnaces, Gas Heated .....	355
Gas Arc Lamps .....	355
Gas Globes, Wire .....	358
Gas Irons .....	355
Gas Logs .....	355
Gasoline Gas Machines .....	357
Gauges, Gas Pressure and Recording.....	349
Glassware for Lamps .....	358
Governors and Regulators .....	354
Head Protectors .....	144
Heating Systems, Gas .....	346
Heaters and Gas Grates.....	355
Holders, Gas, and Tanks.....	353
Hydrogen Gas Apparatus .....	151
Industrial Gas Appliances .....	355
Industrial Instruments .....	125
Ironing Machines, Gas .....	355
Iron Work, Gas .....	353
Lamp Posts .....	355
Lamps, Gas Mantle .....	355
Lamps, Street .....	355
Machinery for Gas Works.....	353
Mains, Pipes for Gas. ....	354
Main Tools and Materials.....	354
Mantles, Gas .....	355
Meter Connections .....	354
Meter Diaphragms .....	354
Meter Provers .....	354
Meters, Gas, Consumers .....	354
Meters, Station .....	353
Mica Chimneys .....	357
Oil for Gas Making.....	776
Paint, Gas Holder, Etc. ....	773
Photometers .....	130
Pipe Fitters' Tools and Materials.....	354
Pipe Fittings .....	354
Pipe Specials .....	354

	Official classification index
Producer Gas Plants .....	353
Purifiers, Gas .....	353
Purifying Oxide and Material.....	353
Pyrometers .....	349
Ranges and Gas Cooking Appliances.....	355
Retort Charging and Drawing Machine.....	353
Retorts, Coal Gas .....	353
Safety Appliances .....	448
Scrubbers, Gas .....	353
Silica Brick .....	767
Structural and Plate Work.....	786
Tanks, Oil .....	776
Tar Extractors .....	353
Testing of Gas, Apparatus for.....	353
Thermometers, Indicating and Recording.....	349
Tools for Gas Making.....	353
Trench Digging Machines .....	354
Valves for Gases or Liquids.....	354
Water Gas Apparatus ....	353
Water Heaters, Gas .....	355

It will be seen from the list of possible exhibits submitted that your Committee has secured the opportunity of proper awards. The Exposition officials have given us hearty co-operation. We are assured that the Exposition is progressing very satisfactorily, and the feeling in San Francisco is that the European War will help rather than hurt the Exposition. The people of the United States have confidence in the success of the Exposition.

Your Committee recommends to the Directors of the American Gas Institute that action be taken to give wide publicity to the possibility of awards for meritorious exhibits of the gas industry at the Panama-Pacific Exposition in 1915, and that a committee be appointed by the American Gas Institute to co-operate with the exposition officials to earnestly invite representative exhibits worthy of the importance of the gas industry.

PAUL DOTY, *Chairman,*  
 J. M. MOREHEAD, *Secretary,*  
 E. G. COWDERY,  
 O. O. THWING.

At the conclusion of the reading of his report, Mr. Doty moved the adoption of the same.

The motion was seconded.

MR. W. R. ADDICKS: I would move also that the matter of a committee be referred to the next Board to appoint such committee.

THE PRESIDENT: You accept that as an amendment?

MR. DOTY: Yes.

The motion prevailed.

THE PRESIDENT: The next is a report of the Representatives of the U. S. National Committee of the International Commission on Illumination. I have a written report, which I will not take the time now to lay before the Convention. I will simply say that the old Photometric Commission has been changed now into an International Commission on Illumination, in which the electric people are co-operating with the gas people. Monsieur Vautier, formerly President of the Photometric Commission, is still the President of the International Commission. There has been appointed an Honorary Secretary, Mr. C. C. Patterson, of the British Physical Laboratory. The various countries have appointed their own local committees. Everything was arranged to go ahead in the various countries, Germany, France and England. You can understand, gentlemen, that owing to recent events, work will be delayed.

#### REPORT OF REPRESENTATIVES, UNITED STATES NATIONAL COMMITTEE OF INTERNATIONAL COMMISSION ON ILLUMINATION.

In August, 1913, the International Photometric Commission, formed at the Paris Exposition in 1900, passed out of existence, or rather was merged into the International Commission on Illumination. Action leading thereto was taken at the meeting of the International Photometric Commission in Berlin.

The International Photometric Commission, in which the Institute was represented, was made up exclusively of repre-



sentatives from the National Gas Associations of various countries.

The International Commission on Illumination expanded the field so as to have representatives from the electric lighting field as well as the gas lighting field.

At the session at which the change was made referred to above, *i. e.*, in Berlin in August, 1913, there were present representing the American Gas Institute, Messrs. Edw. P. Hyde and Alten S. Miller.

The organization of the International Commission on Illumination includes a National Committee in each country represented. The United States National Committee is composed of three members accredited to that committee from each of the following societies:

American Gas Institute,  
American Institute of Electrical Engineers,  
American Physical Society,  
Illuminating Engineering Society,  
and one representative from the United States Bureau of Standards.

The International Commission includes three bodies:

1. An Executive Committee, composed of the President, three Vice-Presidents, an Honorary Secretary, a Treasurer and two representatives named from each country.
2. A Bureau, composed of the President, the Honorary Secretary, assisted by a General Secretary, appointed, and the Treasurer.
3. All delegates from the National Committees or National Technical Societies, depending upon the method adopted by each country.

The members appointed to represent the American Gas Institute on the United States National Committee are:

W. H. Gartley,  
C. O. Bond,  
Alten S. Miller.

The Chairman of the United States National Committee is Edw. P. Hyde, Ph. D., Cleveland, Ohio, who has also been elected a Vice-President of the International Commission on Illumination. The Secretary is Clayton H. Sharp, Ph. D., New York City.

The representatives upon the Executive of the International Commission on Illumination appointed by the United States National Committee are: W. H. Gartley and C. O. Mailloux.

The work of the International Commission on Illumination is to secure an agreement between the different nations represented, in the nomenclature of lighting, and eventually what is considered good practice in lighting; to endeavor to agree upon international units, and to conduct all the work relating to the lighting field that could be made of an international character.

The Honorary Secretary of the International Commission is Mr. C. C. Patterson, of the National Physical Laboratory, near London, and a Secretary has been selected.

The contribution of \$100 which the Institute, in common with the American Institute of Electrical Engineers, Illuminating Engineering Society, and others, contributed, is to defray the expenses of the Secretary's office both here and abroad.

It is believed that there will be some difficulty in the immediate future in arriving at any agreement with scientists on any subject relating to lighting.

W. H. GARTLEY, *Chairman*,  
C. O. BOND,  
ALLEN S. MILLER.

# REPORT OF PRESIDENT OF UNITED STATES NATIONAL COMMITTEE OF INTERNATIONAL COMMISSION ON ILLUMINATION FOR THE YEAR 1913-14.

In accordance with the statutes of this Committee, I beg

to submit the following report for the year closing November 1st, 1914:

Although the organization of the National Committee and subsequent organization of the International Commission on Illumination were consummated more than a year ago, it may be advisable to refer briefly to these two important steps of organization in this first annual report. Subsequent to overtures made to the International Photometric Commission by the American Gas Institute, supported by other societies of the United States, and in anticipation of the re-organization of the Photometric Commission into the International Commission on Illumination, steps were taken looking to the formation of a National Committee on Illumination in this country. To this end an organization meeting was held July 18th, 1913, at which the Bureau of Standards and the following Technical and Scientific Societies were represented:

American Gas Institute,  
American Institute of Electrical Engineers,  
Illuminating Engineering Society,  
American Physical Society.

The representatives of these bodies organized a National Committee on Illumination, in accordance with the proposed statutes of the projected International Commission, and furthermore elected delegates to represent the United States at the Conference to be held in Berlin, August 27th-30th of that year.

It is only necessary to state most briefly that the Berlin Conference came to a successful conclusion in the re-organization of the old Photometric Commission into the new International Commission on Illumination with the adherence of ten nations. In the following November the organization of the U. S. National Committee, as an integral part of the International Commission on Illumination, was confirmed by the U. S. National Committee subject to the approval of the various bodies represented in the Committee. This action was subsequently approved by these various societies, thus formally

establishing the adherence of the United States to the International Commission through the National Committee.

In accordance with the statutes of the International Commission on Illumination, the United States was called upon to contribute towards the expenses of the Commission to the amount of £50. To this end the National Committee voted that each of the three Technical Societies represented on the Committee, *viz.*, the American Gas Institute, the American Institute of Electrical Engineers, and the Illuminating Engineering Society, be requested to contribute \$100 each for the ensuing year, the balance over and above the dues to the International Commission to be applied toward defraying such expenses as may be necessary in carrying out the work of the National Committee. These funds were collected and the dues from this country were forwarded on Dec. 8, 1913. The principal source of expenses in connection with the International Commission is the maintenance of the Assistant Secretary. Mr. Patterson, the Honorary Secretary, has notified this Committee of his consideration of various candidates for the position of Assistant Secretary, but up to the present time, no notification of appointment has been received, so that it is questionable whether the office of the Commission has been fully established as yet.

I regret the occasion that makes it necessary to include in this report a statement of the death of Herr Weiss, Treasurer of the International Commission. As yet no successor to Herr Weiss has been elected.

Owing to the international complications which have arisen, no further progress has been made in the development of the plans of the International Commission. The U. S. National Committee has, however, inaugurated plans for promoting the objects of the Commission in so far as it is possible for the Committee to go. At a meeting of the Committee held in February of this year, it was voted that the last report of the Committee on Nomenclature and Standards of the Illuminating Engineering Society should be submitted to the International

Commission on Illumination for its consideration, as a basis of international action on this question. It was also voted that a communication be sent to the Honorary Secretary stating it to be the opinion of this Committee that it would be useful to bring together a digest of lighting legislation in the various countries represented on the Committee, and that the materials for such digest would be most readily made available if each National Committee would undertake to present a digest of lighting legislation in its own country.

Furthermore, it was voted that the Executive Sub-Committee of the National Committee be requested to devise ways and means of stimulating researches of primary standards and heterochromatic photometry. The Executive Sub-Committee in pursuance of this request recommended investigations of the following problems:

1. Methods of heterochromatic photometry.
2. Light filters.
3. Co-operative standardization of filters.
4. Objective photometry.
5. Primary standards.

A circular letter was sent by the Secretary of the Committee to a number of laboratories asking that, if possible, investigations of some, or all, of these questions be undertaken. Favorable replies have been received from several laboratories and I am glad to be able to state that some research work has already been begun. Owing to the unfortunate situation in Europe, little hope can be had of many results being accomplished for the present in foreign countries and I am impelled to urge the increased importance of activity of the U. S. Committee, in order that the life of the Commission may be fostered.

Respectfully submitted,  
EDW. P. HYDE, *President*.

The President called on Mr. J. A. Gould for the following report:

## REPORT OF REPRESENTATIVES ON JOINT NATIONAL COMMITTEE ON ELECTROLYSIS.

The Joint National Committee on Electrolysis is composed of three representatives from each of the following Associations:

American Institute of Electrical Engineers,  
American Electric Railway Association.  
American Railway Engineering Association,  
National Electric Light Association,  
American Telephone and Telegraph Company,  
Natural Gas Association of America,  
American Gas Institute,

and one representative of National Bureau of Standards.

The American Water Works Association was invited to appoint representatives, but has not yet decided to do so.

Meetings of the Joint Committee were held on February 25th and 26th, when the Committee organized with B. J. Arnold, of Chicago, as Chairman, and Dr. E. B. Rosa, of Washington, as Secretary.

The members of the General Committee were assigned to act on one or more of four sub-committees suggested by the Plan and Scope Committee.

The work assigned to these sub-committees was:

1. Principles and Definition.
2. Methods and Analysis of Surveys.
3. Foreign Practice.
4. Domestic Practice.

The American Gas Institute is represented on the 2d, 3d and 4th Committees, Mr. von Maur being Chairman of Committee on Methods and Analysis of Surveys, and Prof. Ganz is a member of Committee on Domestic Practice.

A meeting of the General Committee was held in New York City on September 14th, when informal verbal reports of progress were made.

It is hoped by the General Committee that the sub-committees can complete their reports in November, preparatory

to action on the final report by the General Committee at a later date.

Although your Committee has nothing definite to report at this meeting, it wishes to state that important data have been collected by members of the General Committee.

The President and the Chairman of the Committee on Foreign Practice have toured England and the Continent in search of information to guide the Committee in compiling its report.

J. A. GOULD, *Chairman*,  
A. F. GANZ,  
J. D. VON MAUR.

MR. G. T. MACBETH (Mount Vernon, N. Y.): I move that the report be adopted and the Committee continued.

The motion was seconded.

MR. W. R. ADDICKS: I do not think you can continue any Committee with the present ruling. We can recommend to the next Board to continue.

CAPT. WILLIAM E. MCKAY: By the action of the Institute last year the Committee is discharged on the filing of the report, and the Technical Committee of this year, the report of which has been adopted, has arranged its recommendations for the incoming Board, to renew the appointments where they are advisable.

I hope Mr. Macbeth will modify his motion.

MR. G. T. MACBETH: I accept.

THE PRESIDENT: Mr. Macbeth modifies his motion to the effect that the report of the Committee be accepted and the continuation of the Committee's work be recommended to the Technical Committee for next year. All those in favor will please say aye. (Ayes.) Contrary no. (No response.) It is so ordered.

The next subject is the Report of the Committee on the Uniform System of Accounting, Lewis Lillie, Chairman. Is Mr. Lillie in the room? (No response.) Is Mr. Curran here?

(No response.) Is there any member of that Committee present who desires to make any statement in connection with the report? (No response.)

The President then called on Mr. R. B. Harper for the following report:

#### REPORT OF THE BUREAU OF INFORMATION.

The Bureau of Information appointed by the Technical Committee for the business year 1913 to 1914 submits the following report.

The work of the Bureau of Information for the 12 months extending from October 1, 1913, to October 1, 1914, may be summarized as follows:

Unanswered questions, prior to Oct. 1, 1913.....	24
Total questions received, Oct. 1, 1913, to Oct. 1, 1914	99
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Total number of questions.....	123
Answers given to questions asked prior to Oct. 1, 1913	28
Answers given to questions asked from Oct. 1, 1913, to Oct. 1, 1914.....	104
Total number of individual questions answered from Oct. 1, 1913, to Oct. 1, 1914.....	90
Questions remaining unanswered, Oct. 1, 1914.....	32
Answers by members at large.....	42
Answers by members and others solicited by Bureau of Information .....	46
Answers by individual members of Bureau of Infor- mation .....	7
Answers by Bureau of Information.....	37
<hr/>	
Total answers .....	132

It will be noted that the number of answers published exceeds the number of questions answered, due to the fact that your Committee in a number of cases obtained two or more answers to the same question.

In order to show the growth in the number of questions and answers thereto since the Bureau of Information was established, the following table is given:



Business year	Questions asked	Answers given
1906-1907 .....	8	8
1907-1908 .....	32	30
1908-1909 .....	15	15
1909-1910 .....	14	14
1910-1911 .....	10	10
1911-1912 .....	48	34
1912-1913 .....	109	106
1913-1914 .....	99	132

The foregoing statistics of the work covered by the Bureau of Information show that of late years the number of questions asked have increased considerably. This appears to indicate increasing interest of the members, and readers of the *Gas Institute News* in the work covered by the Bureau of Information. The members of your present Bureau regret that the interest shown seems to be a stimulated one rather than one originating within the individual members and others. Apparently the interest displayed is somewhat dependent upon, and proportional, to the publicity given to the advantages of the Question Box. Your present Bureau has endeavored to call to the attention of all gas men, the existence of the Question Box and the value of participation in the sending in of questions and answers pertaining to problems of the gas and allied industries. We have done this by means of notices in the *Gas Institute News*, and believe the method has been productive of good results.

Your present Bureau of Information has followed the practice of the past in that it did not assume responsibility for opinions expressed, endeavored to prevent the publication of answers in such form that they might be considered as advertising in nature, and respected the wish, whenever expressed by the author of an answer, that his name be not published in connection with the answer given.

Answers to questions remaining unanswered for some time or those which were somewhat difficult, were solicited by the Bureau of Information from men whom we thought qualified to give valuable information on the respective subject matters of the various questions. In most cases, as a last resort, mem-

bers of the Bureau prepared answers to questions concerning which information was not readily volunteered by the members at large.

Practically all answers received were published, and due credit given the author unless otherwise desired. It was thought that inasmuch as the Bureau did not, and could not very well assume responsibility for the correctness of the opinion expressed, all answers of a non-advertising nature should be published.

Your Bureau of Information appends an alphabetical list of answered questions, to show where they are to be found in the *Gas Institute News*.

R. B. HARPER, *Chairman*,  
L. R. DUTTON,  
C. N. JELLIFFE,  
H. B. MCLEAN,  
G. I. VINCENT,  
A. D. LITTLE,  
D. D. BARNUM.

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1913-1914.

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Accounting—fuel account.....	III	262, 263
Accounting—meter capacity telltale.....	III	163
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THE PRESIDENT: The Bureau of Information has, I think, this year exceeded all former efforts, and it seems to me that no question put by the Bureau of Information in the *Institute News* should go without a great many answers being given. The questions that I noticed, and I think I noticed them all, were of a particularly practical nature, apparently so simple that one or two cases were submitted that had a trap laid for them. I remember in one case the question came up, "Why should you take snow off the top of a holder?" When the question first came out, in the office in which I hold forth, in Philadelphia, a number of my associates were there, and I think all answered the question at once; then they revised their answer and stated what they meant when they gave the first answer; then they revised that again, and at the end of the week they were still working on some answer that they had given, but that did not entirely cover the situation. It seems to me that the Bureau of Information should be a joy to those men particularly connected with the business who are junior members and who get the *Institute News*, possibly through the subscription furnished by their company. I think those men should be encouraged to pay particular attention to it. Again, I think the Question Box is one of the important functions of the *Gas Institute News*. I should like to take more time in talking about what the functions of the *Gas Institute News* are and what they are not; but certain it is that the Bureau of Information, being a business closely associated with the working of the Institute, encroaching on no other publication's work, and of vital interest to the development of the business, should be continued in the *Gas Institute News*.

and should be cultivated. What is your pleasure regarding the acceptance of the report?

MR. W. R. ADDICKS: I move that it be accepted, placed on file and published.

The motion was seconded and carried.

THE PRESIDENT: Next in order is the report of the Committee on International Uniform System of Pipe Threads. Mr. W. Cullen Morris, Chairman.

Mr. Morris then read the report of the Committee as follows:

#### REPORT OF COMMITTEE ON INTERNATIONAL UNIFORM SYSTEM OF PIPE THREADS.

Your Committee has held several meetings during the year with a similar Committee of the American Society of Mechanical Engineers. At these meetings instructions were prepared for transmission to the delegate of the American Gas Institute to the Committee on the International Standardization of Pipe Threads. The reasons calling for these additional instructions will be found in the *June News*.

W. CULLEN MORRIS, *Chairman*,

ALTEN S. MILLER,

H. L. UNDERHILL.

MR. W. CULLEN MORRIS: I might say, Mr. President, that since making this report I received a further letter which was transmitted to Mr. Herr, Chairman of the Committee of the American Society of Mechanical Engineers, stating that practically all of the negotiations with the Committee had been broken off.

The President then called on Mr. J. B. Douglas, Chairman of the Committee on Accident Prevention.

## REPORT OF COMMITTEE ON ACCIDENT PREVENTION.

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### WORK OF COMMITTEE.

When our Committee was appointed last April, the question of obtaining from members of the Institute, accident reports to form the basis of analyses of causes and effects was considered and in May the following circular letter and inquiry blank were mailed:

Office of

CHAIRMAN, COMMITTEE ON ACCIDENT PREVENTION

1401 Arch Street, Philadelphia, Pa.

DEAR SIR:

Will you help us to be of assistance in preventing accidents by reporting cases on the enclosed blanks, a supply of which has been sent you?

Upon receipt of the information desired, we will make analyses to determine the predominating causes of accidents and the order in which they occur. We will then suggest measures to reduce accident frequency in the industry.

Kindly bear in mind that we wish to begin analyzing cases as soon as possible, and send us as many reports as you can. I would suggest reporting from both old and new records.

We shall be glad to forward additional blanks as desired.

Very truly yours,

J. B. DOUGLAS,  
*Chairman.*

# **REPORT OF ACCIDENT** TO EMPLOYEE OF

(NAME OF COMPANY REPORTING)

(CITY)

(STATE)

FOR USE OF AMERICAN GAS INSTITUTE IN STUDYING ACCIDENT PREVENTION

TO BE MAILED TO J. B. DOUGLAS, CHAIRMAN  
ACCIDENT PREVENTION COMMITTEE  
1401 ARON ST., PHILADELPHIA, PA.

ACCIDENT DATE? 191. HOUR OF DAY? DAY OF WEEK?

WEATHER? LIGHTING?

AGE OF EMPLOYEE? YRS. OCCUPATION?

HOW LONG IN COMPANY'S EMPLOY?

EMPLOYED IN DEPARTMENT (DISTRIBUTION, MANUFACTURING,  
COMMERCIAL OR CONSTRUCTION)

CAUSE OF ACCIDENT, INCLUDING CIRCUMSTANCES LEADING TO SAME.

## EFFECT OF ACCIDENT, INCLUDING

(A) NATURE OF INJURY

(B) ACTUAL NUMBER OF DAYS OF DISABILITY

OR, ESTIMATED " " " " "

(C) ACTUAL MEDICAL EXPENSE \$

OR, ESTIMATED " " \$

(D) ACTUAL AMOUNT OF ALL OTHER PAYMENTS TO OR FOR INJURED \$

OR, ESTIMATED " " " " " " " " "

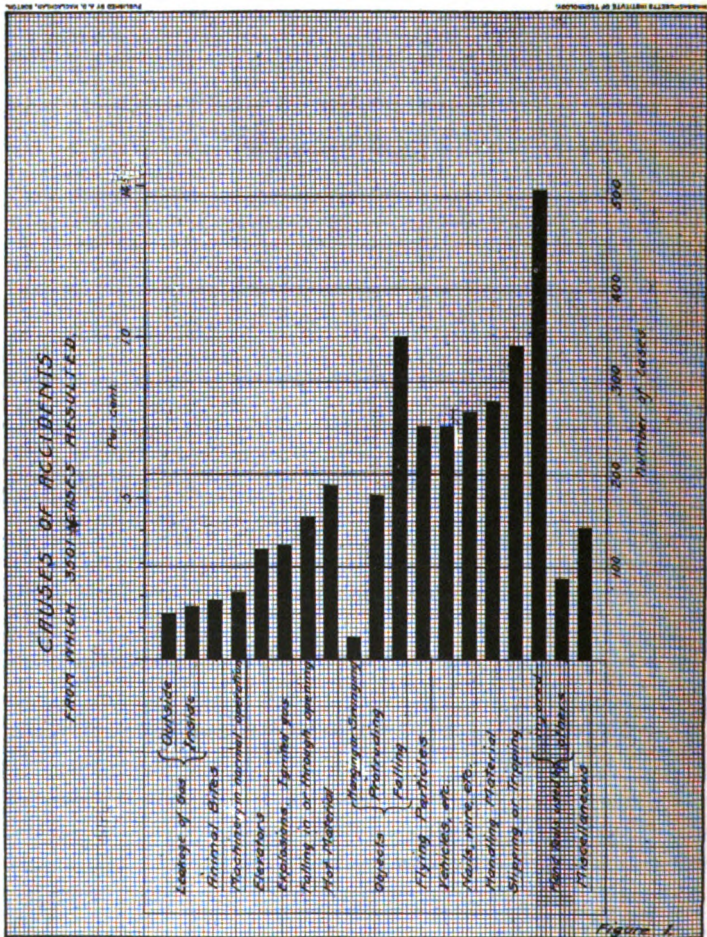
WHAT DEVICE OR PRECAUTION WOULD PREVENT RECURRENCE?

DATE OF THIS REPORT SIGNED



A comparatively small number of reports were received in response, and on July 22nd a second circular letter, reading as follows, was sent out by the Chairman:

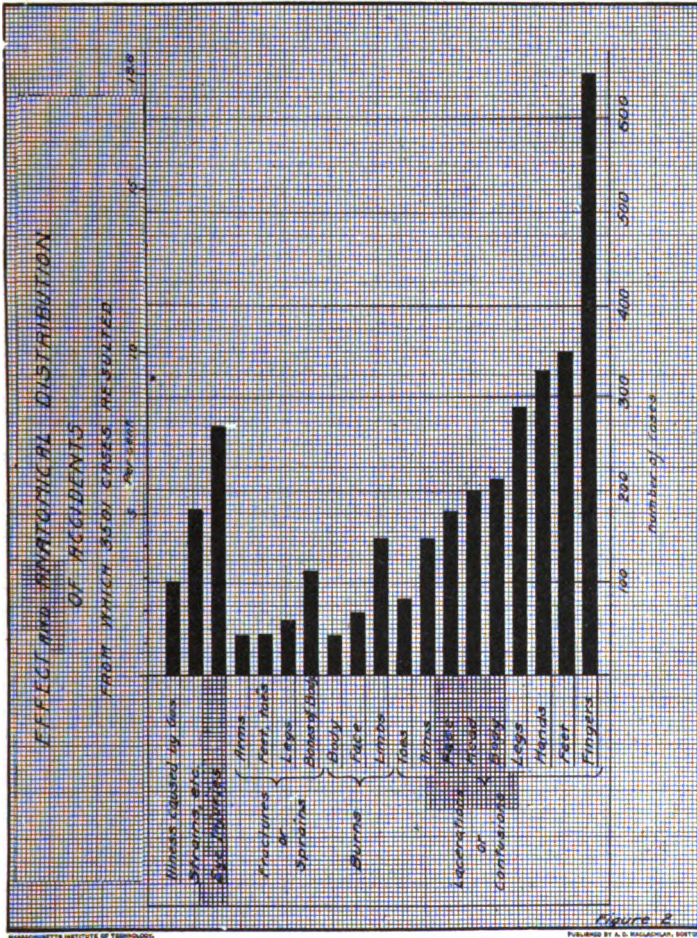
Some weeks ago we sent you a circular letter referring



to the reporting of accidents to our Committee and enclosed therewith a number of report blanks.

I find no record of having received any reports from

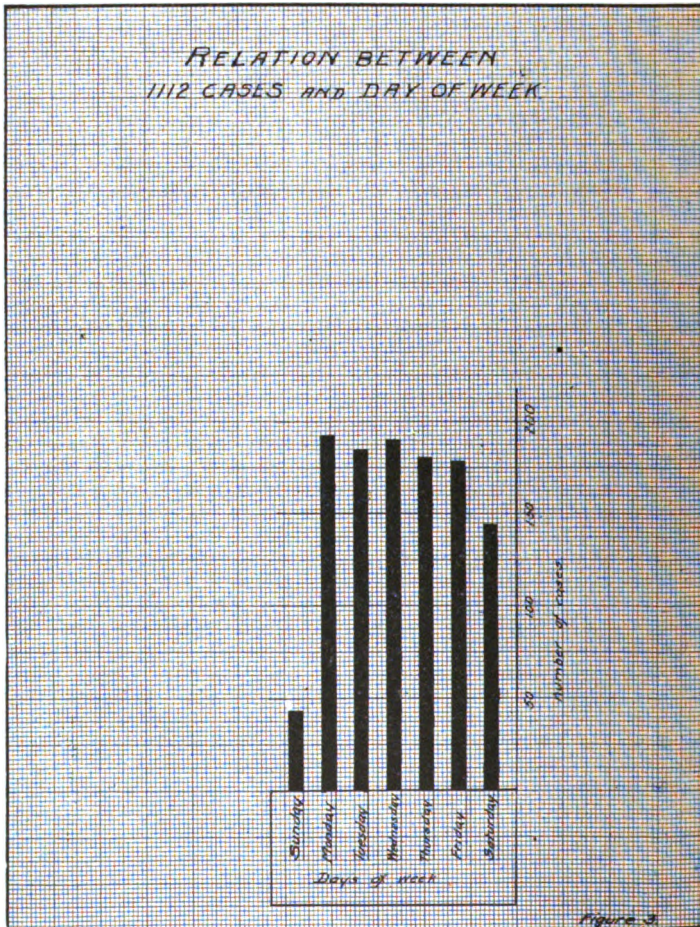
you. Won't you kindly look into the matter and send in the desired information? If no accidents have occurred since you received our letter, I would suggest sending





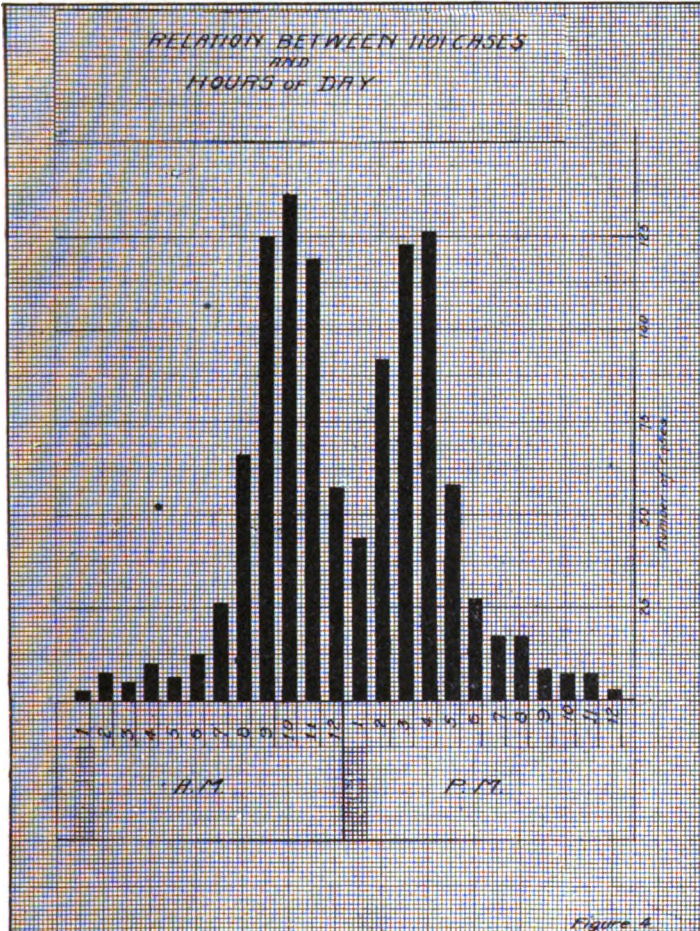
as complete and useful as possible, I want to include something from you. Won't you kindly give the matter early attention and let me hear from you?

From 86 sources in 29 states we have received and analyzed



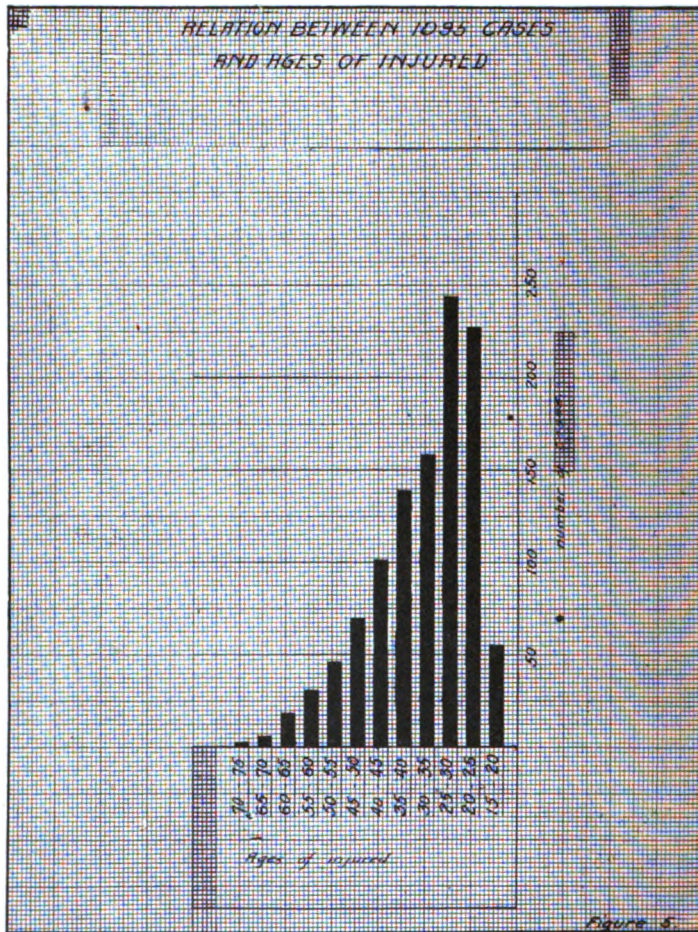
some 3,500 reports of employee accident cases to date, as shown by Figs. 1 to 5 herewith. The total number of

answers to questions on the accident blank in some cases was insufficient to warrant including in the analysis.



It is believed that Figs. 1 and 2 furnish valuable statistical data. Figs. 3, 4 and 5, however, are included as matters of interest.





In each of the five charts, Figs. 1 to 5, eleven fatal cases have been included due to the following causes:

1. Caught in pulley of coal conveyor.
2. Struck on head by falling coal.
3. Struck by street car.
4. Thrown by skidding motor-cycle.
5. Burned by hot tar.
6. Coke buggy struck latch and opened door of generator.
7. Coaling door of experimental generator not clamped.
8. Falling from cylinder head.
9. Overcome by gas while tapping mains.
10. Same.
11. Same.

## OCCUPATIONS.

The occupations reported in 1,033 cases were as follows :

Bench doctor .....	1	Stillman.....	6
Elevatorman .....	1	Floorman .....	7
Salesman .....	1	Collector .....	8
Screenman .....	1	Pipeman .....	8
Crusherman .....	1	Boilermaker .....	8
Quencher .....	1	Blacksmith .....	9
Buggyman .....	1	Gas inspector.....	9
Ashman .....	1	Utility man.....	10
Rigger ....	1	Engineer .....	11
Flue cleaner .....	1	Clerk .....	11
Tinsmith .....	1	Cokeman .....	11
Serviceman..	2	Meterman .....	13
Station operator .....	2	Mechanic....	17
Exhausterman .....	2	Caulker .....	18
Watchman .....	2	Repairman .....	20
Oiler .....	2	Complaintman .....	21
Retort house operator ...	2	Gas maker .....	25
Cellarman .....	2	Orderman .....	30
Press operator ....	2	Fireman .....	31
Charger .....	3	Driver. ....	31
Superintendent .....	3	Stoker .....	33
Mason .....	3	Meter reader.....	40
Janitor .....	5	Foreman .....	62
Stableman.....	5	Helper .....	86
Storekeeper .....	5	Fitter .....	131
Clinkerer .....	6	Laborer .....	314
Carpenter .....	6		
		Total.....	1,033

## SAFETY ORGANIZATION.

Co-operation being the keynote of success in preventing accidents, it is important at the outstart to enlist the interest and active support of officers and workmen. This interest can usually be aroused through a safety rally, at which the plan and scope of the work should be pointed out by the Manager or Superintendent. An outside speaker on accident prevention attracts additional interest, as do lantern slides and motion pictures.

Remarkable success has come to many companies which have pursued safety work systematically. The matter of a safety

organization for the average gas company has been taken up and the following simple plan is recommended:

The organization to consist of:

- (a) General Safety Committee or Department;
- (b) Employees' Safety Committee.

Committees to be constituted as follows:

- (a) The General Safety Committee to consist of a Chairman, appointed by the President or General Superintendent, a Safety Inspector, and three other members appointed by the Chairman.
- (b) The Employees' Safety Committee to consist of a Chairman, who should be the Manager or Superintendent, or his assistant, and three members, appointed by the Chairman, from the Manufacturing, Distribution and Commercial Departments.

This formation should result in a wide distribution of interest so essential to successful safety work.

The duties of the General Committee should be to consider recommendations of the Employees' Committee, and to issue instructions bearing on accident prevention to the several departments. The General Committee should have full authority over the Employees' Committee. It should meet at least once a month, compile and issue information of interest, and devise ways and means of keeping employees alive to the importance of exercising care in their work.

The duties of the Employees' Committee should be mainly to make weekly inspections of the shops and plants, and to refer to the General Committee such recommendations as seem sound and involve expenditures above a limit to be set by the General Committee. The Employees' Committee should receive accident prevention information from the General Committee and spread it among fellow employees. The Employees' Committee should meet with the Safety Inspector at such convenient times as are designated by him. New cases and hazards should be gone over thoroughly and prevention

work and ideas discussed at such meetings. Special joint meetings of the Committees should be called promptly in the event of a serious accident of peculiar interest, to consider measures to avoid recurrence.

Changes in the personnel of the Employees' Committee should be made from time to time by the Manager or Superintendent in order to inform the employees about accident prevention work and widen their interest.

Wherever the size of the company will permit, it is thought advisable to form additional safety committees in each department or plant.

Where the plan is carried out as suggested, it is believed that gratifying results will demonstrate the advisability of continued systematic efforts towards the prevention of accidents.

#### RULES AND PRECAUTIONS.

In addition we have made up a list of precautions intended to prevent accidents in the several departments of a gas company. Owing to the limited time at our disposal and the fact that our "meetings" have been carried on by correspondence, we have endeavored to confine our work to suggesting everyday safety rules and precautions. These should prove helpful in combating the majority of accidents occurring in the gas industry.

For several reasons we have endeavored to omit methods of operation and practice.

#### GENERAL PRECAUTIONS.

*Reporting Defects.*—All employees should be instructed to report at once defects and conditions liable to cause accidents.

*Machinery.*—All moving parts of machinery and belts abutting passageways or exposed to contact, should be guarded or screened.

Machinery should not be oiled or cleaned while in motion, except where the installation of extensions, etc., has been made with this view in mind.

Set screws protruding from shaft collars, pulleys, etc.,



should be covered or replaced by headless set screws. Shaft ends extending beyond collars and containing key or key slots should be covered.

Emery or other dry abraiding wheels should be equipped with safety hoods and eye shields. Goggles are also recommended.

*Elevators.*—Floor openings should be cased in and self-closing gates installed in front of openings to elevators at each floor level. The casing and gates should be high enough (say 7 ft.) to prevent a person extending head over gates into shaft. They should extend to floor to prevent material from falling into shaft.

Counterweight shafts should be encased from base to a height of at least 8 ft.

Toe guards should be provided at each floor to prevent persons riding on elevator from getting feet caught between elevator platform and ceiling or floor extension. Other extensions into shafts should be guarded in a like manner.

Elevator platforms should have fence guards at sides and back. Top of elevator car should be covered with heavy wire mesh guard to protect persons on platform from being struck by material falling into shaft.

A flooring or heavy wire mesh guard should be placed under sheaves and machinery at top of elevator shaft.

Safety terminal stops should be placed on starting cable at upper and lower levels, and lock stop should be installed at each floor level.

There should be at least 3 ft. clearance between under side of elevator platform and bottom of elevator pit when elevator is at lowest point. Landing posts in pit are advisable.

Elevator, cables, sheaves, etc., should be regularly inspected.

*Passageways.*—Passageways should be kept well lighted. Swinging doors should have clear wired glass panel at eye level.

Obstructions and depressions in passageways, paving, side-walks, etc., should be eliminated.

Steam, water or other pipe lines extending across passageways should be placed below level of passageway, or raised high enough to give head clearance.

*Floorings.*—Loose and raised floor boards should be fastened in place; broken and splintered boards removed and protruding nails hammered down.

Where floors are slippery from oil or grease, they should be sanded and the cause of such condition removed as far as possible.

Coverings, such as linoleum, etc., should be kept in repair and securely fastened in place.

Small holes in floors likely to catch shoe heels should be covered.

*Stairways.*—Hand rails should be provided for all stairs. Stairways should be well lighted and free from obstructions. Broken or splintered treads should be repaired.

Floor openings to stairways when not cased in, should have guard rails; also floor risers to prevent material from falling on stairs.

Bars or guard rails should be placed across window openings, particularly on stairways.

Worn and slippery metal treads should be roughened or replaced. Abrasive metal treads are suggested.

*Scaffolding.*—Scaffolding, either temporary or permanent, should be of substantial construction and provided with guard rails if over 5 ft. above level. Scrap lumber should not be used for such purposes.

Planks, boards, scaffolds, etc., resting on overhead ledges or beams should be removed or fastened securely in place.

Tools and material should not be allowed to remain lying on scaffolds.

*Overhead Footways.*—Planks or other footwalks or passageways overhead, should be of sufficient width (say 24 inches) to give ample footing, and should have hand rails on one or both sides and risers where over passageways. Tools and material should not be left on overhead footways.

*Electric Switches, Wires, Etc.*—All electric switches, circuit breakers, rheostats, etc., of 220 volts or more, should be enclosed.

Close inspection should be made of all wiring with which persons might come in contact. Defective insulation should be immediately repaired.

Portable electric lamps for use around machinery, etc., should be enclosed in substantial insulated guards. The lamp sockets should be inspected for defects in insulation.

Unskilled employees should not be permitted to repair switches, fuses, lights, etc.

All wiring should conform to the Electrical Code of the National Board of Fire Underwriters.

*Ladders.*—Care should be exercised to see that ladders are of sufficient strength and length for the purpose used.

Straight ladders should be equipped with hooks, safety spurs or feet.

All ladders should be regularly inspected and kept in good repair. Those beyond repair should be destroyed at once.

Permanent ladders should be installed wherever practicable for the use of oilers, etc.

Ladders to roofs and platforms should extend a distance of 3 ft. above the roofs; rungs should be omitted above roof level.

Bracings, steps, hinges, etc., of step-ladders should be closely inspected.

*Glass.*—Broken window lights should be removed immediately to avoid injury due to falling glass. Pieces of glass should be promptly removed from floors.

Care should be exercised to keep broken glass off passageways in yard.

*Loose Bricks, Etc.*—Loose bricks, cap stones, etc., in chimneys, on top of walls, offsets or ledges, or over door and window openings, should be removed or rebbed. Defective cornices, gutters, rain-spouts and pipes should be promptly repaired. Roofs should be inspected periodically and loose

slates made fast. Provision should be made to prevent snow sliding from roofs. Icicles should be removed.

Loose boards and material should be removed from scaffolds roofs of buildings, etc.

*Gates, Doors.*—Gates fronting on roads or footways should be hung so as to slide or swing in. Periodical inspections should be made of hinges, tracks and carriers. Doors and swinging gates should be fastened in either open or closed positions.

*Covers.*—Pit, well and valve box covers when in or abutting passageways, should be flush with same.

Covers should be recessed for handles so that they will not protrude above level of cover.

*Oils.*—Lubricating oils, paint oils, kerosene, alcohol, gasoline, etc., should be stored in oil house separated from other buildings, if possible.

Pentane should be kept in a cool place, preferably in a pipe or case underground.

No smoking or exposed flame should be allowed in oil house or garage.

*Entrances.*—Entrances to yards should be kept closed or guarded. Outsiders should be admitted only on permission of proper authority. Children, especially, should be kept out.

*Miscellaneous.*—Frequent inspection should be made by the foreman of hand tools and appliances used in his department. Defective tools should be immediately withdrawn from service until repaired.

Tools and bars should be kept in boxes or racks when not in use.

All blocks, pulleys, ropes, cables, and chains should be inspected before being put in use.

Material stored on overhead platforms and beams should be made secure.

Toe boards or risers should be installed on edges of platforms to prevent falling of material.

Tools and other articles should not be stored or placed on top of lockers, closets, etc.

Gas jets, where extending into or along passageways at face level, should be raised or removed.

Hooks, nails or other objects protruding from walls into passageways at face level or lower should be removed.

Shelves for containers of chemicals should be equipped with risers.

Protruding nails should be removed or hammered down.

Hammers with scored heads should be used in rough work to prevent nails flying.

Guard rails should be placed across all window openings, especially where window opening is near floor.

Ladders, pipes, bars, etc., when carried on vehicles should not extend from rear of vehicle, but when unavoidable, they should be at height to give head clearance to pedestrians.

Where hose connection is used on compressed air line, a cock or valve should be immediately behind the outlet nozzle. The hose should not be kinked to cut off pressure.

In the handling of heavy material, care should be exercised to assign a sufficient number of men to the work.

Bricks or spalls should not be used to block up overhead pipe lines. Pipe hangers or blocks of wood securely fastened in place are suggested.

Goggles should be worn by men handling molten solder, lead, etc.

Horizontal exhausts into passageways should be removed or provided with vertical extensions.

Foremen should be careful not to allow inexperienced men to operate machines, or perform other work of dangerous character without giving full instructions as to safe methods of operation.

*Slogans.*—Slogans being useful in helping to keep alive interest in accident prevention work, the following are suggested. They may be used as signs and on letterheads, pay envelopes and cards.

No Accidents.

Safety and Efficiency Go Hand in Hand.

Prevent Accidents ; Popularize Safety.

Safety—Everywhere—Always.

The Safe Way is the Best Way.

The Best Way is the Safe Way.

Taking Care,—Not Chances, Means Safety.

Safety Pays.

Don't Have Accidents.

Safety—Care—Caution.

Boost for Safety.

Carelessness is Dangerous.

The Safe Way is the Right Way.

Safety Preserves Life and Happiness.

Be Careful.

Prevent Accidents.

Follow the Safe Way.

Accident Prevention Saves Misery and Money.

Think about Safety.

*Warnings, Signs.*—Employees should be instructed :

To promptly replace any safeguards removed.

Not to wear ragged clothing and to guard against their clothing being caught in machinery and belting.

Not to carry lighted pipes, cigars, cigarettes or exposed flame into places where there is any smell of gas or likelihood of an explosive mixture being present.

Not to work above or below elevators unless the latter are first made inoperative.

Not to tie up or prop up elevator gates.

Not to hang additional weights on safety valves, dampers or regulators.

Not to open or close any valve or switch or start any machinery with which they are not familiar, nor to remove from same any warning or danger notice unless so instructed by some one in authority.

Not to leave tools or material on ladders, scaffolds or other overhead places from which they might fall and cause injury.

**DANGER**

No. 1

**RAILROAD  
DANGER**

No. 4

**DANGER  
DO NOT TOUCH**

No. 2

**FIRE EXIT**

No. 5

**NO SMOKING**

No. 3

**SAFETY  
FIRST**

No. 6

**DANGER  
NO SMOKING  
KEEP FIRE  
AWAY**

No. 7

**MAN IN BOILER  
DO NOT OPEN VALVE**

No. 8

**CAUTION  
DRIVEWAY**

No. 9

**WARNING  
BLOW HORN  
BEFORE CROSSING**

No. 10

**PREVENT  
ACCIDENTS**

No. 11

**BE CAREFUL**

No. 12

Not to permit temporary scaffolds to remain in position after they have served their purpose.

Not to use any defective tools or appliances, but to turn them in at once and thereby avoid injury to themselves or to fellow workmen.

To invariably use goggles while chipping metal or scale; while working at dry grinding wheels; bulling standpipes or engaged in other work where there is a danger of foreign matter getting into eyes.

To wear respirators and goggles when cleaning out combustion chambers, smoke-boxes, or working in an atmosphere heavily charged with dust.

Foremen should be instructed never to allow one man to undertake any job where there is a likelihood of his being exposed to live gas.

The use of signs as illustrated below, is suggested. Those numbered from 1 to 6 inclusive, have been adopted by the National Association of Manufacturers and other trade associations. Arrangements have been made to secure these signs printed on linen, size 7 in. x 18 in., through the Secretary of the Institute, at 60 cents per dozen.

The signs numbered 7 to 12 inclusive, are not kept in stock but can be readily made up locally.

All signs excepting Nos. 3 and 6 to have white letters, red background. Nos. 3 and 6, white on green background.

#### MANUFACTURING DEPARTMENT.

*Engine Room.*—Rail or screen guards should be placed around fly and belt wheels and pits for same. The lower panels of rail guards should be covered with mesh wire, or a



floor riser should be installed around pit opening to prevent tools or other material from dropping therein. Rail or screen guards should be placed in front of all belts and pulleys along passageways. If main belt runs above passageway, a bridge guard should be placed directly under the belt and across the passageway.

High speed engines in addition to having governors, should be equipped with automatic safety stops and speed limit devices.

Provision should be made for oiling machinery when same cannot be temporarily stopped, from outside of guard rails. Oil pipe extensions and long-spout oil cans are suggested.

Railings should be placed around all overhead engine platforms or walk-ways.

Employees should not feel bearings, etc., of machines while same are in motion.

Floors should be kept as free as possible from grease. Slippery floors should be sanded and the cause removed if possible.

Repairs should not be made to pipe, especially steam, lines while under pressure.

*Boiler Room.*—When boilers are connected in battery, a non-return valve should be installed between the boiler and header. Blow-off from each boiler should be a separate line, or each boiler connection should be equipped with a cut-out. Blow-offs should preferably discharge into a sump. Where steam from sump is liable to cloud a passageway, a ventilating pipe should be carried at least 10 ft. above foot level.

When a boiler is out of commission undergoing repairs, steam valve, feed water valve and blow-off cock, should be tightly closed and locked, and a sign hung on valve reading "Man in boiler,—do not open valve".

Quick closing, lever handle, chain or rod pull, or automatic sealing cocks should be placed on water glass columns.

Safety valve outlets should have vertical extensions to prevent steam from injuring persons on top of boilers.

Tools or extra weights should not be placed on safety valve levers, where they are likely to be overlooked.

Steam line outlets should discharge vertically

Outlet of surface blow-off, if not connected to discharge line, should lead into ash pan.

Water lines for wetting ashes should not be strung against boilers, owing to the likelihood of employees being scalded by what they expect to be cold water.

Fire tools and bars should be kept in racks when not in use, and not left leaning against boilers or walls or on the floors.

Loose bricks on top of walls or boiler sets should be removed or rebedded.

Floors in front of boilers should be kept free of coal, cinders, etc.

*Retort House.*—Charging and discharging machines should be equipped with automatic terminal stops, and also bells or whistles to automatically give notice of change of position. Wheel guards should be provided to avoid foot injuries.

Fuel should not be left scattered on floor.

Floor openings over hot coke chutes should be covered when not in use to prevent material from falling on men in cellar. Cotter pins and nuts on buggy axles should be frequently examined.

Reversing wheels on dumping carriages and sprockets of conveyors should be completely guarded.

Belts, wheels, gears, etc., on coal crushers should be guarded.

Fire tools and bars should be kept in racks when not in use, and not left leaning against walls or on floors.

*Generator House.*—Frequent inspections should be made of floor plates to see that they have proper bearing.

Workmen engaged in clinkering should guard against hot coke dropping in shoes, which should be snugly laced.

Clinkering bars should be equipped with guards to prevent hand injuries. Sledging bars should be held by tongs.

Seal pots should be covered or guarded.

Open ends of, and openings in operating floors should be provided with guard rails, and with toe guards or risers to prevent coal, tools, etc., from dropping on workmen.

Generator coaling doors should be securely fastened.

Pipe extensions should not be used on screw stems of cotter bars to give extra leverage.

No naked lights or flame should be allowed near wash box while same is being cleaned.

Oil lines should be provided with cut-offs outside of building.

*Purifier and Oxide House.*—If gas wall lights are used, recesses should be hermetically sealed from the inside of the building. If electric lights are used, they should be equipped with keyless sockets and the switches located on the outside of the building.

Cleaning of purifier boxes should not be done by less than two men.

Matches and exposed lights should not be allowed in purifier house under any circumstances.

Guards should be placed on wheels of box-lid carriers.

On doors and entrances to purifier house, signs reading as follows should be hung "Danger, No Smoking, Keep Fire Away."

*Blower Room.*—Intake ports in side casings of blowers should be guarded or covered with meshed wire.

*Coal Shed and Trestles.*—When coal and coke are being removed from bunkers or under trestles, care should be taken to see that pieces are not allowed to remain on the tops of stringers, beams, etc.

Trestles should be equipped with foot-walks and hand-rails outside of tracks.

Bars about 12 in. apart should be placed across openings between tracks over hoppers.

In emptying drop-bottom cars, a safety wrench should be used or two men should be employed,—one man to use wrench, the other to release the latch or pawl, one tooth at a time.

Naked flames should not be taken into air laden with coal dust.

All persons should be warned to keep off smouldering coal piles and cinder dumps because of the likelihood of stepping into hidden fire.

Ladders leading to walk-ways should be regularly inspected. They should be fixed or permanent where practicable.

*Holders.*—Stairways and platforms to holders should have intermediate rails in addition to hand rails. There should also be an intermediate rail on galleries in front of siphons. (In adjusting the siphons the operator is usually in a stooping position, and his body is below the hand-rail guard.)

Straight ladders to holders should be provided with cage guards.

When stairways to holders are accessible to public, they should be guarded by gate and screens.

Holder pits should also be guarded.

*Tar Separators, Etc.*—Covers or guard rails should be placed on or around tar separators, pits and stills.

*Tanks.*—Roofs and hatch covers of tanks should be made of substantial material. Open tanks should be provided with floats and life lines.

Gas and oil tanks should be carefully purged before being entered. As an extra precaution, workmen entering tanks should wear life lines, held by others outside the tanks.

*Yards.*—Scrap lumber, fittings, pipe, etc., should be stored where they will be least likely to cause accidents.

Valve stems and boxes protruding above ground should be lowered to ground level or have guards placed around them.

Stakes, etc., should be removed where practicable.

Pipes, stop-boxes, fittings, etc., should be securely stacked.

Danger flags and lanterns should be attached to guy ropes at face level.

Exposed platforms and runways should be well drained and kept free from dirt, ice and snow.

When breaking up cast iron or other metals, goggles should be worn.

Railroad frogs, switches, etc., should be blocked to prevent catching workmen's feet.

Warning signs should be placed at railroad crossings.

Where doorways open directly on railroads, openings should be guarded by safety bars and signs.

#### DISTRIBUTION AND COMMERCIAL DEPARTMENTS.

*Storeroom.*—All bins, shelves, and other storage places should be equipped with risers of sufficient height to keep material from falling into passageways, and care should be exercised to prevent overfilling bins. The contents of bins should be so arranged that they will not protrude into passageways.

Alleyways between bins should be well lighted and kept free from obstructions.

Pointed bars or tools should be stored in proper receptacles with points down. Heavy tools should be stored as near floor as practicable.

Appliances such as water heaters, radiators, etc., when stored in piles should be stacked securely to prevent falling.

Fixtures, material, tools, etc., suspended overhead should be made secure and should be high enough to afford ample head room. Hooks should be used instead of nails for suspending articles.

Nails should be removed from barrels and the top of boxes before unpacking.

Material should not be stored on window ledges. Window openings near piles of material should be guarded by wire mesh screens or risers.

*Driveways.*—Driveways where possible should be guarded by gates. If a gate is impracticable, a sign should be conspicuously displayed, warning pedestrians and others of the existence of the driveway.

Motorcycles should not be ridden across footways nor into or out of yards and buildings.

Horns of all motor vehicles should be sounded before vehicles are driven across footways. The local rules and ordinances bearing on the operation of motor vehicles should be learned and observed.

*Garage and Stables.*—Garage floors should be kept as free from oils and grease as possible; slippery floors should be sanded and the cause removed where practicable.

Oils, gasoline, etc., should be stored in a separate building away from garage or stable.

Automobiles, motorcycles, other power driven vehicles and bicycles should be regularly inspected.

All motor vehicles should be equipped with lamps and horns; bicycles with lamps and bells. Wagons should carry lamps.

All horses and mules should be reasonably safe and steady, and should be in charge of experienced drivers only. If inclined to bite, horses should be muzzled; if inclined to kick or run away, they should not be retained. Horses should be securely tied or weighted when left alone.

All harness, vehicles, etc., should be regularly inspected.

No smoking or use of exposed flame should be permitted in or around garage or stable. Signs reading, "Danger, no smoking, keep fire away," should be posted.

*Shops.*—Cutting and other tools, fittings, etc., should not be left lying around where persons may step on same.

Gears, belts, pulleys, band and circular saws, planers, etc., should be guarded.

Nails should be kept in receptacles and not allowed to become scattered on floor.

Goggles should be worn where there is a danger of foreign matter entering eyes.

Scrap material should be removed and not permitted to remain on floors.

Oil cans, files, etc., should be kept out of the way where persons will not be likely to fall or step on same.

*Excavations and Trenches.*—In cutting paving or pipe, when chips are liable to fly, canvas or other shields should be set up along footways. Goggles should be worn.

Trenches should be braced or shored, or the sides sloped to lessen the likelihood of caving.

Trenches and open manholes in traveled districts should be barricaded. All trenches should bear danger signs by day and red lights by night. Lanterns should be filled, trimmed and inspected before using.

Paving stones, bricks, etc., should be securely piled or stacked and should be kept off the line of travel except when used for barricading.

Tool carts, dirt or other street obstructions should be guarded by danger signs or red lights. Tool carts should be kept off highways at night as far as practicable.

In distributing pipe or lamp posts along streets or trenches before laying, care should be taken to see that they are secure and that the ends do not extend over street crossings into roadways or footways.

Inspections of newly filled trenches should be made from time to time and depressions refilled.

The greatest care should be used in the handling of dynamite, which should be delivered as far as practicable, in the smallest quantities and only as required.

*Miscellaneous.*—When cleaning windows from outside of building, cleaners should wear safety belts.

Safety rubber stops should be placed between pairs of sliding elevator doors to prevent injury to operators' hands.

Pointed desk files should be guarded or pointed ends bent over.

Telephone wires, electric fan wires, etc., should not be strung across floor passageways.

Stop boxes should not be allowed to protrude above surrounding levels.

*Fitters, Complaint-Men, Meter Readers, etc.*—Should beware of vicious dogs on consumers' property.

Should see that openings in floors, trap doors, cellar doors, etc., used by them are either closed or the openings guarded while they are on premises, and securely closed when leaving.

Should see that meters are securely supported.

Should test out all gas appliances after connecting.

Should report all leaks immediately.

Fitters should always make meter and housepipe tests after turning on gas, to guard against leaks and open outlets.

Condensation should not be left on consumers' premises. If spilled, it may be deodorized with vinegar.

In handling condensation employees should exert utmost care to avoid fire or explosion. If it is not to be saved, it should be burned on paper in the open, by and in the presence of employee.

Fire should never be used to thaw out a frozen pipe or meter.

The *Institute News* has been publishing monthly contributions from our Committee in the forms of lists of "accidents which might have been prevented," with precautionary suggestions and photographs of hazards.

Safety buttons are used to advantage in keeping the subject of accident prevention before employees and the public. After all is said and done, it is the prevention spirit that accomplishes more than any other factor towards avoiding accidents. Buttons bearing appropriate slogans help to stimulate interest and to maintain the prevention spirit.

Our Committee advocates the use of safety buttons and suggests that the one reproduced on the cover of this report be adopted as the standard for gas companies.

It is the thought of the Committee that in next year's work should be included a scheme for standardizing accident statistics, the preparation of a motion picture film on accident pre-



vention and the compilation of a standard book of instructions on First Aid.

In closing, the Committee wishes to express appreciation of the help given it by members of the Institute, and regret and some disappointment over the lack of co-operation evidenced by several of the larger company members. The Committee trusts that its results, incomplete as they are, will be useful to all and will serve as an incentive to the said companies to contribute their share towards the success of the new committee.

Respectfully submitted,

JAS. B. DOUGLAS, *Chairman*,  
C. M. COHN,  
WM. MCGREGOR,  
C. E. REINICKER,  
G. O. SMITH,  
R. E. SLADE,  
J. W. SCHAEFFER,  
H. B. HOYT.

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#### ADDENDA.

The data from which the following analyses were made was received after the Committee's report went to print. As the data refers to manufacturing accidents only, it could not have been properly included in the main analyses, which are made up of the general run of cases from the Manufacturing, Distribution and Commercial Departments of gas companies. To include these manufacturing cases in the main analyses would result in incorrect averages.

It is hoped that the new committee will obtain reports of the distribution and commercial accidents from the same sources for corresponding periods, in order that these cases may be closed into the general analyses, which it is thought the new committee should continue. An "experience" from ten thousand cases is desirable.

## CAUSES OF ACCIDENTS FROM WHICH 750 CASES RESULTED.

	No. of cases	Per cent.
Leak of gas, outside .....		
Leak of gas, inside .....		
Animal bites.....	2	0.26
Machinery in normal operation .....	35	4.67
Elevators .....	1	0.13
Explosions, ignited gas... ..	21	2.8
Falling in or through openings .....	28	3.73
Hot material.....	40	5.34
Hanging or swinging objects .....	18	2.4
Protruding objects .....	40	5.34
Falling objects.....	168	22.4
Flying particles .....	40	5.34
Vehicles .....	32	4.27
Nails, wires, etc. ....	47	6.27
Handling material.....	62	8.26
Slipping and Tripping .....	80	10.66
Hand tools used by injured .....	77	10.25
Hand tools used by others .....	16	2.13
Miscellaneous .....	43	5.75
<b>Totals .....</b>	<b>750</b>	<b>100.00</b>

EFFECTS AND ANATOMICAL DISTRIBUTION OF ACCIDENTS FROM  
WHICH 750 CASES RESULTED.

	No. of cases	Per cent.
Illness by gas .....		
Strains .....	16	2.12
Eye injuries .....	36	4.80
<i>Fractures or sprains.</i>		
Arms .....	9	1.20
Feet.....	4	0.53
Legs .....	11	1.47
Bones of body .....	8	1.06
<i>Burns.</i>		
Body .....	4	0.53
Face .....	13	1.75
Limbs .....	38	5.06
<i>Contusions or lacerations.</i>		
Toes .....	25	3.33
Arms.....	30	4.00
Face .....	36	4.80
Head .....	95	12.70
Body .....	56	7.48
Legs .....	65	8.62
Hands.....	63	8.40
Feet.....	55	7.35
Fingers .....	186	24.80
<b>Totals .....</b>	<b>750</b>	<b>100.00</b>

## RELATION BETWEEN 742 CASES AND AGES OF INJURED.

	No. of cases	Per cent.
15 to 20 years .....	26	3.51
20 to 25 " .....	125	16.85
25 to 30 " .....	151	20.35
30 to 35 " .....	107	14.4
35 to 40 " .....	121	16.3
40 to 45 " .....	88	11.85
45 to 50 " .....	40	5.4
50 to 55 " .....	38	5.12
55 to 60 " .....	18	2.4
60 to 65 " .....	23	3.15
65 to 70 " .....	5	0.67
Totals .....	742	100.00

## OCCUPATIONS.

The occupations reported in 749 cases were as follows:

	No. of cases		No. of cases
Clerk .....	1	Penciller .....	6
Wheelman .....	1	Painter .....	6
Gripman .....	1	Charger .....	6
Door-opener .....	1	Chainman .....	6
Wagonsmith .....	1	Repairman .....	8
Yardmaster .....	1	Standpipeman .....	9
Chemist .....	1	Brakeman .....	10
Watchman .....	1	Trackman .....	10
Drainman .....	1	Tarchaser .....	11
Quencher .....	1	Fitter .....	17
Store-keeper .....	2	Foreman .....	18
Weigher .....	2	Oiler .....	18
Blacksmith .....	2	Motorman .....	20
Coke bagger .....	2	Fireman .....	25
Conductor .....	2	Driver .....	27
Gas maker .....	3	Luter .....	34
Mud-mixer .....	3	Carpenter .....	44
Stevedore .....	3	Machinist .....	54
Stableman .....	3	Boilermaker .....	57
Moulder .....	3	Engineer .....	62
Ironworker .....	3	Laborer .....	75
Electrician .....	5	Helper .....	77
Gas-tender .....	5	Trimmer .....	95
Mason .....	6		
Total .....		749 cases	

MR. J. B. DOUGLAS (Philadelphia): Mr. Chairman and Gentlemen, on behalf of the Committee on Accident Prevention, I am very glad to make the above report. When our Committee was appointed last spring, the question of obtaining accident reports to form the basis of analyses of causes and effects was considered, and in the following month a circular letter was sent out soliciting answers on especially prepared forms which the Committee arranged. The answers to that letter were not what we had hoped they would be, and we sent out an additional letter, which brought us in all some 3,500 cases. We analyzed those 3,500 cases in several ways, the principal one being with regard to causes and another relating to effects. It might be interesting to mention, in going over this hurriedly, what is revealed by the form of "peaks." You will notice on the first chart that the peak is due to the use of hand tools. That is always high in our industry, the same as in the general manufacturing industry.

The slipping and tripping hazard you will notice is prominent, also falling objects, giving us some idea of the points to be attacked, to be looked for in endeavoring to reduce accident frequency. I might mention, gentlemen, that a number of companies are to-day effecting a saving of from 15 to 50 per cent.; they have so reduced the number of accidents occurring annually that the saving in estimated and actual expense has ranged from 15 to 50 per cent. and even more during the first year.

The second schedule of effects simply shows the different portions of our anatomy to bear in mind when subject to accident hazard. We have also included several charts, which I think are rather interesting, although I do not know just how useful they are. One of them shows the relation between 1,112 cases and the days of the week. You will notice that the peaks are very generally distributed. I might mention, gentlemen, that these figures are made up from 86 sources in 29 states, giving a good general average. The relation between cases and hours of the day I think is rather

interesting. It has some bearing possibly on the fatigue hazard. Turning to page 87, you will notice, taking a day, starting at 7 o'clock, that there is a gradual rise until the peak is reached around 10 o'clock; and assuming that work would be resumed around 1 o'clock in the afternoon, you will note a gradual rise until the peak is reached at about 4 o'clock. It is rather curious, I think, that the peak, which may be a fatigue peak, should be reached practically the same number of hours after beginning and resuming work.

You will also notice, on page 88, an outline of the relation between 1,095 cases and ages of the injured. It is also surprising, I think, that the peak in those cases is between the ages of 25 and 30, giving us some idea of the men on whom we should make a special effort to impress the seriousness and importance of accident prevention work. On page 89, you will notice an analysis of 1,033 cases has been made by occupation. It indicates that in attacking this problem of prevention, we should go after the laborer first, who leads with a total of 314 accidents; next comes the fitter, then the helper, and then the foreman. I am rather surprised that as high a number as 62 accidents from that total should have occurred among foremen. You will notice, reading on down the line, the general order in which those cases occur. As I stated, marked results are being obtained in accident prevention work, the greatest probably through systematically following out and tracing up the causes of accidents and resorting to organization for safety endeavor. I want, therefore, to read to you, if I may, what we have said regarding safety organization: "Co-operation being the keynote of success in preventing accidents, it is important at the out start to enlist the interest and active support of officers and workmen. This interest can usually be aroused through a safety rally, at which the plan and scope of the work should be pointed out by the manager or superintendent." In working this out, we have endeavored to provide a committee which should take care of the average company. Of course, it will

have to be modified to suit the company, large or small. On page 90 we say: "The organization to consist of:

"(a) General Safety Committee or Department;

"(b) Employees' Safety Committee.

"Committees to be constituted as follows:

"(a) The General Safety Committee to consist of a Chairman, appointed by the President or General Superintendent, a safety inspector, and three other members appointed by the Chairman.

"(b) The Employees' Safety Committee to consist of a Chairman, who should be the Manager or Superintendent, or his assistant, and three members, appointed by the Chairman, from the manufacturing, distribution and commercial departments."

The idea is to interest the several departments as much as possible in the work.

"The duties of the General Committee should be to consider recommendations of the Employees' Committee, and to issue instructions bearing on accident prevention to the several departments. The General Committee should have full authority over the Employees' Committee. It should meet at least once a month, compile and issue information of interest, and devise ways and means of keeping employees alive to the importance of exercising care in their work.

"The duties of the Employees' Committee should be mainly to make weekly inspections of the shops and plants, and to refer to the General Committee such recommendations as seem sound and involve expenditures above a limit to be set by the General Committee. The Employees' Committee should receive accident prevention information from the General Committee and spread it among fellow employees. The Employees' Committee should meet with the safety inspector at such convenient times as are designated by him. New cases and hazards should be gone over thoroughly and prevention work and ideas discussed at such meetings. Special joint meetings of the committees should be called promptly in the event of a

serious accident of peculiar interest, to consider measures to avoid recurrence.

"Changes in the personnel of the Employees' Committee should be made from time to time by the manager or superintendent in order to inform the employees about accident prevention work and widen their interest.

"Wherever the size of the company will permit, it is thought advisable to form additional Safety Committees in each department or plant.

"Where the plan is carried out as suggested, it is believed that gratifying results will demonstrate the advisability of continued systematic efforts towards the prevention of accidents."

On page 91, continuing:

"In addition we have made up a list of precautions intended to prevent accidents in the several departments of a gas company. Owing to the limited time at our disposal and the fact that our 'meetings' have been carried on by correspondence, we have endeavored to confine our work to suggesting every day safety rules and precautions."

I might emphasize, gentlemen, that we tried to be very careful not to go into matters of operation, which might conflict with the work of some of our other committees.

Our experience has shown that the majority of accidents are due to simple little hazards, such as you will note, if you have time to look this report over, and not to serious mechanical or other defects or serious errors in operation.

Now, we have listed here a number of pages of general precautions, which should be useful, I think, in the gas industry in combating the accident hazards.

THE PRESIDENT: All of them based on practical experience?

MR. J. B. DOUGLAS: The majority, in fact, I think all of these suggestions are based on an experience with accident reports, accidents that have actually occurred; and as I mentioned earlier, the majority of these cases showed very clearly

that there was no serious mechanical defect or serious error in operation. As you will notice, by referring to the charts, the majority of the cases were due to simple causes. In the majority of cases, prevention would not even mean the expenditure of any money whatever. Pages 91, 92, 93, 94, 95 and 96 cover general precautions referring to elevators, passageways, floorings, stairways, scaffolding, overhead footways, etc. In connection with the heading scaffolding, at times scrap lumber is used, and this frequently has resulted in accidents, the scaffolding being insecure and poorly put together. You will notice, on page 93, we have drawn attention to this particular cause of scaffolding accidents. Then we take up ladders, and give some suggestions as to how they should be equipped, straight ladders to be equipped with hooks, safety spurs or feet, all ladders to be regularly inspected, etc. I want to draw attention to the fact that ladders, which should be discarded, are not always discarded; in fact, in the majority of instances, broken and defective ladders are allowed to remain where they are likely to get into use. It would seem that the very best place to put a ladder which is beyond repair is under the boilers, where it will be immediately destroyed.

Then we take up glass, (broken window lights) loose bricks, etc. Falling objects, you will remember, made one of the peaks in the chart to which I draw attention, and of course loose bricks and objects of that kind will come under that classification, and loose copings, for instance; objects blown from roofs, if they strike an employee, unusually cause a pretty serious accident.

On page 95 we take up gates, doors. "Gates fronting on roads or footways should be hung so as to slide or swing in. Periodical inspections should be made of hinges, tracks and carriers." We have found that where gates swing out over footways, they are likely to strike pedestrians; usually the head is involved, and in case a claim is made by one of the public, the injury is likely to appear more serious than it would be if it were to an employee, and the cost is always greater.



We go next to covers, oils, entrances. "Entrances to yards should be kept closed or guarded. Outsiders should be admitted only on permission of proper authorities. Children, especially, should be kept out." That is very important. The yards of some plants are not fenced, and serious, even fatal accidents, have occurred to trespassers—children who have gone in, for instance, and tried to climb holders. You will notice the subject of "slogans" at the bottom of page 96, suggestions which can be used to advantage; and on page 98 you will see some danger signs reproduced. As to these danger signs, I have made arrangements for the Secretary so that you may be able to obtain these signs, printed on heavy stock paper, at cost or less than cost, through several of our sister associations—50 cents a dozen. (Showing samples of signs.)

Then we take up corresponding precautions in the manufacturing, distribution and commercial departments.

The Committee has received from The United Gas Improvement Company a set of accident prevention slides which have been successfully used in employees' meetings. If there is time to do it after the meeting this morning, I should be very glad to show those slides before the Convention. It is hoped that the slides will be secured from the Secretary, from time to time throughout the year, and that they will prove useful in the general work of accident prevention. (Applause.)

THE PRESIDENT: As Mr. Douglas has stated, before you go to lunch, he will be able to present those slides immediately after the morning business is finished. This report bears evidence of a great deal of careful work, a great deal of careful analysis. Every large company and almost all of the moderate sized companies, and most small companies spend money towards guarding against accidents. I recall one company in which the amount of money that was spent as the result of the regular inspections was saved for the two following years in the cost of accidents. It may be a coincidence, but it was a

rather striking one. What is your pleasure, gentlemen, with regard to this report?

MR. WALTON FORSTALL: I move the adoption of the report. The motion was seconded and carried.

MR. J. B. KLUMPP (Philadelphia): Mr. Chairman, I thoroughly approve of the work being done by the Accident Prevention Committee, but I think that the future work of this Committee should be subjected to the supervision and approval of the Public Relations Committee. I do not mean that they should report directly to our Committee, but should report as heretofore to the Technical Committee. I believe that there are certain features of their recommendations that might bear modification before being approved and adopted by the Institute.

There are several States in which the "Safety First" principle is being considered in construction legislation, and certain acts and bills are being taken up which, if embodied in regulatory measures, will, to some extent, hamper the operation of our properties and restrict the occupation of our engineers. One State is considering registering and licensing all engineers before they are allowed to do business. Such a measure is generally considered unnecessary and is opposed generally by the profession. These measures are directly a product of the "Safety First" and "Efficiency Engineering" campaigns.

I had several discussions with our *confreres* on the "Safety" subject, and my opposition brought me a post-card which read "Don't Kid About 'Safety First'—You May Be the Goat,"—and I was the "goat," or one of the "herd." I had to go before a Commission and present an argument for the gas men of that State, in opposition to the "Registering and Licensing" bill.

So in the future I believe the Public Relations Committee should have an opportunity of passing upon, and approving, any reports of the Committee on Accident Prevention, before they are adopted by the Institute.

MR. J. B. DOUGLAS (Philadelphia): Mr. President, the Accident Prevention Committee, I think, has rather been under

the wing of the Technical Committee. It likes the Technical Committee very much; the association has been pleasant, but it might be very advisable to follow out the suggestions that Mr. Klumpp has made. There are State laws being advanced throughout the country, laws and ordinances referring to the different structures that have more or less to do with the causes of accidents, and it is certainly very important that they be followed out. I know in our own city we had an accident prevention committee, and a number of opportunities have been afforded the manufacturers to avoid rules and regulations that are impracticable.

MR. WALTON FORSTALL: I should like to amend the motion that I made: That the report of the Committee on Accident Prevention be adopted, and that the appointment of a new Committee on Accident Prevention be recommended to the Committee on Public Relations.

CAPT. WILLIAM E. MCKAY: Under the Constitution that we adopted to-day, we continued that provision which designates, as the duty and privilege of the President, to determine to what Committee to assign any work. Therefore, I do not think that any specific action is either necessary or desirable as to designating the Committee to which this Sub-committee should report. Mr. Douglas's Committee work falls within the care of the Technical Committee. I hope that Mr. Forstall will modify his motion and accept the report, with the thanks of the Institute, and allow the incoming administration to continue the work as it sees fit.

MR. R. M. SEARLE (Rochester, N. Y.): I should like to direct the attention of the Institute to the question of whether safety first as now carried on throughout the country is being sufficiently impressed upon the employee as to his individual responsibility by his discharge when he has an accident? "Safety First" to-day has gotten to be a fetish that has very largely, in our own organization at home, become what I think is "hot air." The men have so much of it that they are beginning to feel; What's the use?—In fact, one of our fore-

men made the statement that an operator we had in our organization said that the company did not give any credit to a man whether he had an accident or whether he did not have accidents, when, as a matter of fact that very day he had been given credit in discussion and recommendation to raise his wages for it. This shows the lack of co-operation or sympathy on the part of the individual.

In railroad traffic, when a man has an accident with his train, he is never allowed to take out a train again. You can readily see the reason, and it seems to me that there ought to be a standard of punishment for the man who, by his thoughtlessness, inflicts terrible suffering upon his fellow beings. The fact that he has served the company for years should make no difference.

We had a case where at 1 o'clock in the morning an automobile chauffeur, a Scotchman, a line inspector, who operates his own machine, happened to meet an intoxicated man, who now brings an accident suit against the Company for \$15,000—and I presume he would settle that case for a considerable sum, but this Scotchman had had his regular glass of ale before he left home and, although he had never been intoxicated, so far as we know, during his 19 years of employment, the Coroner and the Police Officers say to-day that they will not testify that this man was not drunk, because his breath smelled of liquor. There was a man accustomed to climbing poles, handling hot wire and driving an automobile, and a drunken man stepped in front of his auto, got knocked down and was very severely injured, but there was the Coroner and the Police Sergeant who will not go on the stand and testify that the man was not drunk because they smelled alcohol on his breath. Doesn't it seem, if we are going to be punished to the tune of \$25,000 or \$30,000 a year in a large organization for accidents of that kind, that we have got to direct our attention to the man who does drink liquor—notwithstanding the fact that the executive officers do? The difficulty is this. Take an individual man in an analysis such as Mr. Douglas has

made, you will find that there are certain men who are either the cause of or have more accidents happen to them than any other men; and frequently, out of 100 accidents, it may be either by direction or indirection, 20 of them are caused by one individual man. That man ought to be discharged, I don't care if he has been with you 20 years; he simply will not stop having accidents. If he is going to continue to inflict upon his fellow beings terrible punishment by his thoughtlessness, he should be severely dealt with. I want to bring to the notice of the Institute that it seems to me we have gone as far as we can in humane leniency toward our men, who do not appreciate the responsibility that rests upon them in the conservation of human life and prevention of human suffering. (Applause.)

THE PRESIDENT: Gentlemen, we will have to close this discussion. All those in favor of the motion to accept the report of the Committee will please say aye. (Ayes.) Contrary. (No response.)

THE PRESIDENT: I will now call on Mr. C. C. Tutwiler, Chairman of the Committee on Exhibits. I think it is necessary that he should explain a few of the ideas that he has in mind.

Mr. Tutwiler then read the report of the Committee as follows:

#### REPORT OF COMMITTEE ON EXHIBITS.

The Committee on Exhibits acting under somewhat general instructions felt that the wishes of the Institute would be carried out if an opportunity was extended to all manufacturers of apparatus, equipment, and other material used in the industry, to participate, the exhibits being limited to apparatus, appliances and material possessing distinctively novel features which had not previously been brought to the attention of the members of the Institute. To this end the Committee sent out a circular letter to practically all advertisers in the *American Gas Light Journal*, *The Gas Age*, and *The Gas Record*, and also to a number of advertisers in the *Journal of*

*Industrial and Engineering Chemistry*, and to others who were known to the Committee or whose names were suggested to them, inviting them to present for the consideration of the Committee a description of any apparatus, appliances or material which in their opinion possessed features of novelty which had been developed within the past year, or which had not been previously brought to the attention of the Institute. Many failed to respond and a few exhibits offered failed to measure up to the requirement of the Committee. We have, however, accepted about 40 individual exhibits which make up the Technical Exhibit shown on the ground floor of this building. We have endeavored as far as possible to eliminate all commercial features and exhibitors have therefore been prohibited from having representatives present or from distributing advertising matter or samples in connection with the exhibit. They were, however, requested to prepare a card of suitable size briefly describing their exhibit and giving an address at which further information could be secured. In some cases it may be found that the description given is not sufficient to fully explain the exhibit; in others the exhibitor has misinterpreted the instructions given in preparing this card, and has combined in a full description matter of an advertising nature, which could not be eliminated at the last moment.

It should be understood, therefore, that the exhibit is intended to be entirely scientific in its character, to show material designed within the last year or possessing novel features which have not been before brought to the attention of the Institute. It is possible that some of the exhibits do not measure up to the standard and there is no doubt that there is existant some material which the Committee would have been glad to show, but which was not brought to its attention.

We have endeavored, however, to place all exhibitors on precisely the same footing, and it should perhaps be said that while the fact that a given piece of apparatus or material was accepted for exhibit does not necessarily carry with it the endorsement of the Institute, at the same time it is hoped that

the exhibitor will see in its acceptance an appreciation of merit which it is a desire of the Institute to encourage.

C. C. TUTWILER, *Chairman*,  
 GEO. S. BARROWS,  
 C. O. BOND,  
 A. C. HOWARD,  
 H. B. McLEAN,  
 J. M. MOREHEAD,  
 C. J. RAMSBURG.

THE PRESIDENT: I think there is no action required on that. The statement Mr. Tutwiler has made is sufficient. The idea of this exhibit was that it is not intended to encroach on the idea that the Institute should not have a general exhibit of any kind, but it was thought by some gentlemen it was not wise, when we come here together, to miss the opportunity of having people show us what are the latest ideas in the way of apparatus.

The next on the program is the report of the Committee on Pipe Standards, to be presented by Mr. W. Cullen Morris, of New York.

#### REPORT OF THE COMMITTEE ON PIPE STANDARDS.

The Institute, in October, 1911, adopted standard dimensions for bell and spigot cast iron pipe and special castings, and in October, 1912, standard dimensions for flanged cast iron pipe and special castings. In October, 1913, the standardization of these castings was completed by the adoption of standard specifications to govern their manufacture. Therefore, your Committee had before it this year no constructive work, but merely the duty of advertising the new standards as completely as possible. This they have done by publishing them in a pamphlet of convenient size, of which over 5,000 copies have now been distributed among users and manufacturers.

To a circular sent to the principal founders, replies have been received to the effect that all renewals of patterns are being made according to the new standards. There is, therefore, every reason to believe that within a very few years these standards will be in universal use for gas work.

As questions are apt to arise from time to time connected with the new standards, your Committee recommends that the next Technical Committee appoint a sub-committee to care for these matters.

W. CULLEN MORRIS, *Chairman*,  
L. R. LEMOINE,  
WALTON FORSTALL.

MR. WALTON FORSTALL: I move the adoption of the report.

The motion was seconded and carried.

THE PRESIDENT: Now, there is one other matter. Is Mr. Curran in the room? (No response.) We are very sorry that we could not have the opportunity of having the gentleman who has prepared the Uniform System of Accounting get up and talk for a few moments, so that he could receive the high praise that is due to the Committee. We are ready, however, to pass that over since we have the report, which I consider one of the most important achievements of this year. That the system of accounts is ready for distribution has been made known in the *Gas Institute News*. Will the Secretary read the report of the Committee?

The Secretary then read the report of the Committee as follows:

#### REPORT OF THE COMMITTEE ON UNIFORM SYSTEM OF ACCOUNTING.

Your Committee, appointed to revise and compare the Uniform System of Accounting adopted in 1902 by the American Gas Light Association with systems of accounting in use by the several State Utility Commissions, having presented its report, which was adopted unanimously by your Board of



Directors at meeting held September 10, 1914, in accordance with authority granted the Board at annual meeting of the Institute held October 14, 1913, now requests its discharge.

Respectfully,

LEWIS LILLIE, *Chairman*,  
S. J. GLASS,  
H. M. BRUNDAGE,  
M. W. STROUD,  
G. W. CURRAN.

MR. W. R. ADDICKS: I should like to move a vote of thanks to that Committee, and using Dr. Humphreys words, it should not be perfunctory. I appreciate the very great difficulty and very great delicacy required in handling the matter placed before them. As a matter of fact, it was a period of two years before they reached a final conclusion, which illustrates the difficulties under which they labored. The matter having been already accepted by the Board, by authority of the Institute last year, requires no action but an action of this kind. I make that motion.

DR. ALEXANDER C. HUMPHREYS: I second it.

THE PRESIDENT: Gentlemen, you have heard the motion. All those in favor, will please say aye. (Ayes.) Contrary, no. (No response.) It is so ordered.

We are through with the program for the morning and the time for adjournment is at hand. I want to say again what I said a few moments ago: The registration shows, I think Mr. Robison told us, more than 500.

THE SECRETARY: Yes.

THE PRESIDENT: More than 500 members of the Institute have registered, and for the present at least there are not 500 men in this room, and I greatly fear that unless you gentlemen take the matter seriously there will be the same small proportion in the sectional meetings that will follow to-day and to-morrow. That would be very unfortunate. The ques-

tion of having 4 sectional meetings is one that will be tried out now for the first time. I particularly call your attention to the Illuminating Section, because it seems to me very evident that the American Gas Institute, dealing with that sort of illuminant that is more commonly used than any other in the country, should not allow its sessions to go by without paying some special attention to illumination. The members of the gas industry in the Illuminating Engineering Society perform a very prominent and very important part, and why they should devote their energies to the Illuminating Engineering Societies and neglect the American Gas Institute, is something that I cannot understand. It has been a fad of mine to have them form an illuminating section this year. I found one or two gentlemen who said that the thing will not work out. It was due solely to the fact that the gentlemen who made that remark—very excellent in their own specialized line—are not acquainted with the wonderful amount of data and information that has been collected by engineers in the Institute who have specialized in illumination, and so do not understand how we could have a successful meeting. The Illuminating Section is under the able management of Mr. C. O. Bond, past president of the Society of Illuminating Engineers. Mr. Bond will no doubt have enough to attract your attention if you will put in your time in that Section. Therefore I ask you to come to these sectional meetings promptly so that they can start at once. The business that they have on hand as indicated in these papers is very large, so do not let us have any comment that sectional meetings will not do, because the people won't attend. In that connection, I would say also that the Committee on Arrangements has purposely left out, too many distracting features of entertainment, to allow the members to go to the meetings, and so put in the time in the way in which they would get the most results.

THE PRESIDENT: The session is adjourned.

Adjourned, 12.35 P. M.

## INSTITUTE MEETING.

Morning Session, Friday, October 23.

W. H. GARTLEY, *President*.

GEORGE G. RAMSDELL, *Secretary*.

President Gartley called the meeting to order at 10 A. M.

We will hear the report on the President's Address. I will ask Mr. Walton Forstall to take the chair.

MR. A. S. MILLER:

### REPORT OF COMMITTEE ON THE PRESIDENT'S ADDRESS.

Your Committee wishes to point out and, as far as possible, emphasize the careful study that has been made by our President of our Institute, and our industry. The results of this study are shown in his address, and we recommend its most careful perusal to all who have the interest of the Institute and the industry at heart. That our President realized this his responsibilities ran far beyond perfunctory recommendations is shown by the fact that many of the suggestions have already been carried out or made possible by the changes in the Constitution adopted at this meeting. One of the changes in the Constitution provides for an increase in the income of the Institute that should make it possible to secure the much needed increase in office facilities.

We recommend this subject to the consideration of the Board of Directors.

We recommend to the members of the Institute the approval of the movement now under way to publish reports of the decisions of the various Public Utility Commissions; and to that end, we offer for your consideration, and, we hope, your adoption, the following resolution:

WHEREAS the large number of Public Service Commissions having jurisdiction over gas interests in the United States makes it desirable that the decisions of such Commissions be adequately reported, indexed and digested in order that the same may be made available.

AND WHEREAS The Gas Institute records its apprecia-

tion of efforts being made to secure such reports. It is therefore,

*Resolved*, That any movement now under way to encourage publication of such reports, which may be satisfactory to the Public Relations Committee, be approved and encouraged, and that the Gas Institute recommends that all members of the Institute and all companies subject to the jurisdiction of such commissions support such movement by subscription to such reports.

ALTEN S. MILLER,  
EDWARD G. COWDERY,  
J. ARNOLD NORCROSS.

THE ACTING PRESIDENT: Gentlemen, you have heard the report of the Committee on the President's Address. The Chair will entertain a motion for the adoption of the report, and after that is made, discussion on the report will be in order.

MR. C. E. REINICKER: I move that the report presented by the Committee on the President's Address, be accepted.

(Motion seconded.)

THE ACTING PRESIDENT: Does anyone wish to discuss the motion? If there is no discussion, we will take a vote on the question. (Motion carried.)

MR. A. S. MILLER: Does that carry the resolution of the Committee?

THE ACTING PRESIDENT: The Chair rules that it carries the recommendation of the Committee.

(Acting President Forstall surrenders the gavel to President Gartley.)

THE PRESIDENT: Is the report of the General Committee on the International Gas Congress ready?

# REPORT OF THE COMMITTEE ON INTERNATIONAL GAS CONGRESS.

SECRETARY RAMSDALL: The report has not been written, but the principal actions taken yesterday can be reported verbally at this time.

The General Committee on International Gas Congress elected Dr. A. C. Humphreys President of the Gas Congress, and also decided that the Presidents of the various Gas Associations who send delegates to attend the Congress, will be appointed Vice-Presidents.

It was also decided to start a campaign or canvass as early as possible, in an endeavor to find out how many will go to the Congress. The matter of papers and programs was left entirely in the hands of the Committee on Papers and Authors.

THE PRESIDENT: You have heard the report of the Committee. What is your pleasure?

MR. WALTON FORSTALL: I move that it be accepted and published in the PROCEEDINGS.

(Motion seconded and carried.)

THE PRESIDENT: Mr. Miller calls attention to the fact that the Constitution provides that the next place of meeting must be decided at this meeting. Of course the place of meeting has already been selected by the Institute 2 years ago; but perhaps it would be wise now to ratify the action of the Institute of 2 years ago.

MR. A. S. MILLER: I move that the next meeting be held at San Francisco in the week beginning September 27, 1915.

(Motion seconded and carried.)

Are the Secretaries of the various Sections ready to present their reports? The Distribution Section is first. We will call on Mr. Reinicker to present the report of the Distribution Committee.

MR. C. E. REINICKER:

#### REPORT OF THE DISTRIBUTION SECTION.

The Distribution Section, during its sessions on Wednesday and Thursday, October 21 and 22 respectively, has received the committee reports and listened to the papers as listed below:

"The Welding of High Pressure Mains," by Mr. J. D. Shattuck; "The Installation and Maintenance of Services," by

Mr. R. B. Duncan; "The Installation, Repairing and Testing of Meters by a Small Company," by Mr. Chas. Otten, Jr.; "The Improvement of Distribution Employees," by Mr. C. E. Reinicker; "The Proper Specifications for an Inspection of Interior Gas Piping," by Mr. A. E. Turner; Report of the Committee on Piping of Large Buildings for Gas, by Mr. O. H. Fogg; Report of the Committee on Utilization of Gas Appliance, by Mr. W. J. Serrill.

These papers and reports have been accepted as presented, for publication in the Institute PROCEEDINGS, and the various recommendations made have been concurred in. The Distribution Section now submits its action in this regard for approval, or amendment, by the Institute.

C. E. REINICKER, *Chairman*,  
JOHN STILLWELL, *Secretary*.

MR. WALTON FORSTALL: I move that the report of the Distribution Section be accepted.

(Motion seconded and carried.)

THE PRESIDENT: The next is the report of the Manufacturing Section, to be presented by Mr. Underhill.

MR. HENRY H. UNDERHILL:

#### REPORT OF THE MANUFACTURING SECTION.

The Manufacturing Section, during its sessions on Wednesday and Thursday, October 21st and 22d, respectively, has received the Committee reports and listened to the papers as listed below:

Report of the Committee on Refractory Materials, by Mr. Herman Russell, Chairman; "Oil Tar Separation, Recovery and Disposal," by Mr. R. E. Wyant; "Coal Gas Residuals—Feld Process," by Mr. F. H. Wagner; "Operating Experiences under a Calorific Standard," (Symposium); "Efficiency Relation Existing Between Various Argand and Open Flame Test Burners," by Mr. F. H. Gilpin; "The Operation of Inclined Retorts," by Mr. Frank Huber; Report of the Committee on Progress in Carbonization Methods, by Mr. E. L. Spencer,

Chairman; "Carbonization in Bulk—Koppers' Ovens," by Mr. C. J. Ramsburg; "Methods and Facilities for Specifying and Testing Blowers, also Measuring Air and Steam Supply to the Water Gas Generators," by Mr. J. M. Spitzglass; Report of the Committee on Measurement of Gas in Large Volumes, by Dr. J. F. Wing, Chairman; "Purifier Installations," by Mr. C. E. Paige; "Care and Maintenance of Gas Holders," by Mr. J. H. Braine.

These papers and reports have been accepted as presented for publication in the Institute PROCEEDINGS, and the various recommendations made have been concurred in. The Manufacturing Section now submits its action in this regard for approval, or amendment, by the Institute.

The Manufacturing Section recommends for consideration at this session the question of the adoption by the Institute of the Carpenter burner as the standard for testing gas.

HENRY L. UNDERHILL,	} <i>Chairmen,</i>
WM. E. MCKAY,	
W. VANALAN CLARK, <i>Secretary.</i>	

MR. WALTON FORSTALL: I move the report of the Manufacturing Section, omitting consideration for the present of the recommendation in relation to the Carpenter burner, be received and accepted.

MR. C. E. REINICKER: I second the motion.

(Motion carried.)

MR. WALTON FORSTALL: I now make a motion that the recommendation of the Manufacturing Section in relation to the Carpenter burner be not adopted.

(Motion seconded.)

THE PRESIDENT: The motion is now before the house. Is there any discussion?

MR. WALTON FORSTALL: The Manufacturing Section undoubtedly had a very good reason for the adoption of that recommendation; at the same time, in the absence of strong support of that motion by the men of the Manufacturing Sec-

tion who made it, and with only a small attendance on the part of the Institute members at this meeting, I think it is much too important a matter to be accepted by the Institute with practically no advance notice to the Institute membership, that a motion of such importance was coming up at this time.

THE PRESIDENT: What were the arguments in connection with that, Mr. Underhill?

MR. H. L. UNDERHILL: There were no arguments. Mr. Bond suggested the motion, and the arguments were to be presented this morning.

THE PRESIDENT: Mr. Bond, do you want to be heard? You were the gentleman who suggested this recommendation to the Manufacturing Section.

MR. C. O. BOND: This came up at the end of the discussion by the Section at the session at which Mr. Gilpin's paper was presented. The paper was the result of a good many months of work and the conclusion reached was one in which a number of people had been consulted, and it is diametrically opposite to the conclusion advocated in the methods and tests set forth by the Bureau of Standards. It seems the question is down to the voting point, as to whether the American Gas Institute wishes to allow this proposal of the Bureau of Standards to go without opposition, or whether they wish to advocate this Carpenter burner. It was adopted in England and is in use now also throughout Canada, and the question now is, whether, with the trend of quality we have in the gas of the United States, it is not time to bring up this matter.

I think personally it is time for the Institute to take this stand, and wish we had a full meeting here in order to have full discussion on that point this morning.

THE PRESIDENT: I can see that one of the difficulties of recommendations made by Sections, based on papers read before each such Section, will be, that in bringing it before the Institute, there will be so many people in the Institute meeting who are not just in touch with the arguments one way or the other. There has been considerable development of the sub-



ject, or development of testing, principally of testing by various carbonization plant methods. Mr. Ramsburg, what is your opinion?

MR. C. J. RAMSBURG: I think if this thing is adopted at this time, and the tests are made in the future on the Carpenter burner, that there cannot be any possible objection from that standpoint. The only objection I can see is whether the Carpenter burner testing will interfere with the testing of high candle-power water gas. Mr. Bond's judgment on this is pretty near final.

THE PRESIDENT: Do you think there will be any serious loss of time if this were referred to the new Technical Committee?

MR. CHAS. O. BOND: I may be wrong in regard to the purpose of these recommendations, but as I understand them, each Section is recommending these different points to the incoming administration, or the Board of Directors. It does not mean that it goes into effect as the opinion of the entire Institute. It means that the Board of Directors has something to think about in this matter, and it has the recommendation of the Section, which has given the most thought to each individual recommendation.

As Mr. Ramsburg says, if you had a high candle-power water gas (above 23 candle-power) you might have some difficulty with the 6-inch chimney. But the principle involved is what I am after.

I do not think many works exist where the adoption of the Carpenter burner for candle-power determinations would be impossible.

MR. C. W. ANDREWS: If we adopt this, it seems to me we are playing into the hands of people who are anxious to put in a double standard. If we bring out the merits of the Carpenter burner, of giving high candle-power on low candle-power gas, the tendency will be to put in a double standard.

MR. WALTON FORSTALL: If it is a good thing to have the Institute adopt this burner, it would be a pity to delay such

adoption until the next meeting, so I withdraw by motion, and move as follows: That the Institute refer the recommendation of the Manufacturing Section to the Board of Directors with authority from the Institute to the Board to adopt that recommendation for the Institute, if the Board, after proper investigation, decides that it is for the best interest of the Institute.

That would enable us in the November or December *News* to announce what we thought of doing, and after proper notice, decision could be made.

(Motion seconded and carried.)

**THE PRESIDENT:** Next is the report of the Chemical Section to be presented by Mr. Blauvelt.

**MR. WARREN S. BLAUVELT:**

#### REPORT OF THE CHEMICAL SECTION.

The Chemical Section, during its sessions on October 22, has listened to the papers as listed below:

"Gas Chemist's Handbook," by Mr. W. H. Fulweiler; "An Electrical Process for Detarring Gas," by Mr. F. W. Steere; "A Method for the Determination of Hydrogen Sulphide in Gas," by Mr. A. B. Way; "Tests of a New Recording Calorimeter," by Mr. C. H. Stone and Mr. W. H. Hinman; "The Separation of the Illuminants in Mixed Coal and Water Gas," by Mr. G. A. Burrell; "The Mode of Decomposition of Coal by Heat," by Mr. H. C. Porter and Mr. G. B. Taylor; "Gas Manufacture from the Point of View of Physical Chemistry," by Mr. W. F. Rittman.

These papers have been accepted as presented, for publication in the Institute PROCEEDINGS, and the various recommendations made have been concurred in. The Chemical Section now submits its action in this regard for approval, or amendment, by the Institute.

The Chemical Section recommends that the Technical Committee appoint a committee to continue work on the "Gas Chemist's Handbook;" that a formal acknowledgement be

made by the Institute to the Director of the Bureau of Mines, thanking him for the co-operation of the Bureau on the work of the Gas Institute, and expressing the appreciation of the Institute not only for the papers presented, but also for the presence of the authors at the meeting.

WARREN BLAUVELT, *Chairman*,  
THEODORE BUNKER, *Secretary*.

THE PRESIDENT: Probably a motion for the acceptance of this report conveying the recommendations to the Board of Directors will be in order.

(Motion made, seconded and carried.)

THE PRESIDENT: The next is the report of the Illumination Section:

MR. C. O. BOND:

#### REPORT OF THE ILLUMINATION SECTION.

The Illumination Section, during its session on October 22nd, has received the Committee report and listened to the paper as listed below:

Report of the Committee on Illumination, by Mr. C. O. Bond, Chairman; "The Physical Installation of Gas Arcs," by Mr. C. A. Luther.

This report and paper have been accepted as presented, for publication in the Institute PROCEEDINGS, and the various recommendations made have been concurred in. The Illumination Section now submits its action in this regard for approval, or amendment, by the Institute.

C. O. BOND, *Chairman*,  
C. W. JORDAN, *Secretary*.

MR. BOND: The last two hours of the session were given over entirely to a discussion as to the necessity for an Illumination Section.

You will remember in the report of the Technical Commit-

tee that this Section was considered an experiment. The purpose of the meeting was to bring out an expression of opinion as to whether or not the Section should be continued in existence.

The recommendation was made at the close of the meeting that the Illumination Section should be continued, but that its activities should be, as far as possible, kept within the bounds of the engineering branch of the gas business. We had quite a number of commercial men present, who claim, and I think with justice, that committees already working under the National Commercial Gas Association were covering territory which might have been included in the scope of the Illuminating Committee without further restriction. The understanding is that the committees of the two organizations would work in harmony.

**THE PRESIDENT:** There was no curtailment to the activities of the Institute in that motion. It was simply the desire of the members that they would work in conjunction with other societies on the subject of illumination. It was brought out very clearly that the future of the illuminating business by gas was largely a question of engineering, and not entirely salesmanship alone. The necessary conditions requiring good service were to be found largely in the engineering portion of the business.

**MR. FORSTALL:** I move that the report of the Illumination Section be accepted.

(Motion seconded and carried.)

**THE PRESIDENT:** Next is the report of the Accounting Section:

**MR. WALTON FORSTALL:**

#### REPORT OF THE ACCOUNTING SECTION.

The Accounting Section, during its sessions on October 22, has received the Committee report and listened to the papers as listed below:

"In Rate-Fixing by Commission: Should Depreciation be Deducted from Plant Valuation," by Mr. A. C. Humphreys;

"Accounting for Depreciation," by Mr. Halford Erickson;  
 "Compensation of Meter Readers," by Mr. H. C. Schaper;  
 "Printing and the Care of Printed Stock," by Mr. W. P. Baylie;  
 "A Suggested Extension of the Dewey Decimal System of Classification to Gas Engineering," by Mr. D. S. Knauss;  
 Report of the Committee on Rates, by Mr. William McClellan, Chairman.

These papers and report have been accepted as presented, for publication in the Institute PROCEEDINGS, and the various recommendations made have been concurred in. The Accounting Section now submits its action in this regard for approval, or amendment, by the Institute.

The Accounting Section recommends that the work of Mr. Knauss be carried on in connection with the American Library Association.

R. C. DAWES, *Chairman*,  
 THOMAS M. LEAHY, *Secretary*.

MR. FORSTALL: I attended the Convention sessions of the Accounting Section, and I wish to say that the percentage of what you might call live matter to total audience was probably higher with it than with any other Section, successful as they all were; and I understand that while the number of speakers in the morning session was not so great, the interest in the morning session was not less than that manifested at the afternoon session.

THE PRESIDENT: Is a motion in order for the acceptance of this report?

DR. A. C. HUMPHREYS: I will make such a motion.

(Motion seconded.)

THE PRESIDENT: The question is before you.

DR. A. C. HUMPHREYS: Mr. President, I was at the morning session. I noticed quite a number spoke and at such length that it gave no opportunity for the readers of the papers to make any remarks, except in my case to express an opinion on my part, which was an expression of indignation.

I think it would be well if the Publication Committee took under advisement the question of Mr. Erickson who brought out some very valuable material as he said, of a very elementary nature, and that is what we want. I think he should be asked or given the privilege of sending in to the Secretary, any remarks that he did not have the opportunity to make for lack of time.

I was asked to supply an abstract of a paper, and I took about 6 minutes, and that was the extent of my opportunity. That is not the way the record of these great Institutions should stand, and in future we must do something to curb the amount of time accorded to each speaker, or else we must make provision for a less number of papers, so that we can finish the discussion.

MR. WALTON FORSTALL: I second Dr. Humphrey's motion. No one knew whether we could get anybody to discuss anything in the Accounting Section; and in the desire to prevent it falling flat, we provided more papers than proved to be necessary. Mr. Erickson's paper was in print only 2 days before the meeting, so we could not make an abstract, and we were compelled to allow him to present his paper in full.

The Publication Committee has all the power necessary to see that what goes into the PROCEEDINGS is properly edited. There is no doubt that the Publication Committee will preserve whatever is of permanent value in the discussions of all the Sections, while omitting what second thought would exclude.

DR. A. C. HUMPHREYS: My point is, we want to extend the courtesy to Mr. Erickson, of asking him to make this full contribution. Our record would be incomplete without it.

MR. H. W. PECK: I would suggest an amendment, that Mr. Erickson and Dr. Humphreys both be requested to submit brochures of their papers.

THE PRESIDENT: The question before you is on the adoption of the report.

(Motion made, seconded and carried.)

THE PRESIDENT: That finishes the Section Reports. Our meeting this year has had several things in the nature of an experiment, and certain rather unexpected results, to my mind, have been brought out. When I requested at the first session of the Institute, that there should be a prompt and full attendance at the Section meetings, I did not realize that the attendance would be larger than at the Institute meeting itself. Mr. Forstall has some figures which I would like to have him read to you, which will show you how the attendance was kept up.

MR. WALTON FORSTALL: I haven't those figures here now, but my intention is to put into the Institute *News* all the lessons to be drawn from the convention; and in that statement will appear the record of attendance. We had the different Section Secretaries counting the attendance 3 times during each session—at the beginning, midway and at the end of the session.

THE PRESIDENT: I know the Accounting Section room was overcrowded, and people were standing in the hall.

MR. WALTON FORSTALL: I will say at least 500 at one time in all the Sections; the Manufacturing Section had 296.

THE PRESIDENT: The idea of carrying the business on in Sections was more popular than most of us had expected. It seems when men's minds are turned in a certain direction, they are anxious to segregate and they give more attention and more enthusiasm on their specialized lines than when they are in a joint session. I think this has established a mark for future Conventions.

THE PRESIDENT: Are you ready to report on the award of the Beal Medal, Mr. Morris?

MR. W. C. MORRIS: I am unable to report. Our Committee has had difficulty in deciding. The Committee believes that there are not enough medals; that the Institute

papers are divided into so many branches, that a Committee has great difficulty in weighing the relative value of papers submitted to the different sections.

MR. WALTON FORSTALL: Could we not authorize the Committee to report to the Board of Directors?

THE PRESIDENT: Yes; that could be done.

MR. WALTON FORSTALL: I move that the Committee on Beal Medal be authorized to report its award to the Board of Directors for publication in the *Gas Institute News*.

(Motion seconded and carried.)

THE PRESIDENT: Is there any other unfinished business before the Convention?

MR. WARREN S. BLAUVELT: It seems to me, Mr. President, before we adjourn, we should have a formal expression of thanks for the wonderfully efficient work which has been performed by the Committee on Arrangements. I have never before in the history of the Institute seen the arrangements planned so well. In each Section we were informed of what was transpiring in all the others. The whole thing is run like a well regulated machine.

We should give our formal expression of gratification and appreciation to this Committee for its very careful planning and skillful execution of that plan. (Motion seconded and carried.)

THE PRESIDENT: There were at these meetings, Mr. Robson informs me, an attendance exceeding 850,—including the ladies. I think he said it was 25 to 30 per cent. beyond the attendance of any former Institute meeting.

It leads to the conclusion that with the Institute as big as it is now, we must appreciate that the number of cities able to accommodate us is being restricted. It is no longer a one man's Convention or even a Convention of the Board of Directors. I cannot imagine any technical or scientific body in which the officers can call for help and get such thorough, efficient, capable Committees as I find in this Institute.

I hope you will all feel how very grateful I am that the year



has gone by with as much success, putting the Institute forward in certain definite ways that we believe will continue, and on behalf of myself and the Board of Directors and the Officers, I thank you most heartily, and I bespeak for Mr. Jones the same hearty co-operation I have received.

DR. A. C. HUMPHREYS: I do not think we should adjourn without expressing our thanks to the Officers and the Committees, and especially the President and the Technical Committee. I think we are particularly indebted to all those who have worked for the success of this Convention, including, of course, the Entertainment Committee; and I hope we will not adjourn until we have given permanent form to our appreciation of our obligations to these men.

I have particularly admired the way in which our President has conducted our Convention, with his usual suavity and dignity and without the sacrifice of efficiency.

MR. A. S. MILLER: I take pleasure in seconding that motion. The suggestion by Mr. Morris stated that he thought that was to a very considerable extent due to the *News*. I want to say I believe the *News* has been a very excellent factor in the success of the Convention, and our thanks are due particularly to the Secretary and to the *News*, and I wish to include in that vote of thanks, an expressions of our thanks to the Secretary for the excellent work he has done in the past year with the *News*.

(Motion seconded and carried.)

(Motion to adjourn made, seconded and carried.)

THE PRESIDENT: Gentlemen, the Ninth Annual Convention of the American Gas Institute, is adjourned.

Adjourned, 10:50 A. M.

## CHEMICAL SECTION.

**Morning Session, Thursday, October 22.**

MR. W. S. BLAUVELT (Detroit): *Chairman*, Presiding.

MR. THEODORE BUNKER (Paterson, N. J.), *Section Secretary*.

The chairman called the meeting to order at 10 A. M.

THE CHAIRMAN: Gentlemen, the Chemical Section of the American Gas Institute will start its first session.

When we consider that the gas industry is primarily dependent upon chemical manufacturing processes, we can see that in the past the gas industry has not given the place to the chemist in its proceedings to which the chemist is properly entitled.

It was the thought of Mr. Gartley and the Board of Directors that the organization of a Chemical Section would be but the proper recognition of the importance of the chemist in the gas industry, and that the objects of the Institute would be promoted by securing the interested and active co-operation of all chemists connected with, or interested in, this industry.

This first year we are making an attempt to see to what extent the chemists in the industry wish to take hold of this work with the Institute. The Committee in charge has succeeded in getting some very interesting papers; I hope they will be very freely discussed, and that the handful of the elect who are here to make history in the gas industry, by starting this section, will tell the other gas chemists that here is a chance to do good work for the benefit of our industry, and incidentally for the benefit of the chemists who are connected with the industry.

The first paper to which we will call your attention is by Mr. W. H. Fulweiler, of Philadelphia, and is his report on the Gas Chemist's Handbook. Mr. Fulweiler, gentlemen. (Applause.)

### GAS CHEMIST'S HANDBOOK.

The preliminary work consisted in making a general survey of the samples submitted for analysis to the laboratory of The

United Gas Improvement Company. It was felt that this would serve as a fair index of the extent of the work that might be expected in the laboratory of an American gas works.

A number of samples were omitted from consideration where they occurred but once, or where they apparently would not be of interest, generally, to the gas industry.

The chemical methods that were used in analyzing these samples were then entered into a card index, and an alphabetical list of the methods and determinations were prepared.

This list is given in Appendix I.

It does not claim to be a complete summary of the entire field, but it is published primarily to bring out a discussion as to what should properly be included in the handbook, for the guidance of future work, there should be a free and full discussion of this proposed table of contents or index.

Upon consideration of the number of analytical methods involved and the fact that in many cases there are a number of methods in use for the same determination, it was thought best to restrict the work of this year to a few of the more important methods, and to give, as far as possible, methods of analysis which had been adopted as standard by societies such as the American Society for Testing Materials, American Chemical Society, the Bureau of Standards, etc.

We have endeavored to cover the principal determinations necessary in the analysis of coal, coke, gas oil, furnace and illuminating gas, tar, oxide and impurities. In several cases, there are no recognized standard methods. In such cases, the liberty has been taken of setting forth the methods which have been used as standard for a number of years, in the laboratories of The United Gas Improvement Company, believing that they are at least sound, workable methods and might well serve as temporary standards.

The methods which we recommend for inclusion this year, in the Gas Chemist's Handbook, are given in Contents.

Several tables that seem to be of considerable value, have

also been included and suggestions as to other desirable data will be welcomed as a guide for future committee work.

Of even greater importance than the choice of standard methods of analysis is the formulation of standard methods of sampling. Upon going into this subject, however, it was found that there was a very great diversity of opinion and practice, and it is earnestly recommended that future committees should give special attention to this phase of the subject. The methods of sampling given in this report are those that appear to be the most serviceable at the present time, and in this connection, reference should be made to the bibliography on methods of sampling given in Appendix III.

It would seem that the handbook would be best published in the form of a folder with loose leaf inserts, so that in case there is a change made or an advance in the art, the revised methods could be readily slipped into place.

This would further have the advantage that, whereas, the preliminary work may involve only a few methods, as succeeding work is done, the additional methods could be slipped into place without disturbing the indexing or the original character of the book.

The magnitude and delicacy of this work is fully realized and this is presented primarily as a progress report. In time, the Institute would be well repaid for the expense incurred in the publication of such a handbook by the uniformity of practice that would result from the adoption of these methods and by the convenience to the gas chemist of having recognized standard methods pertaining to the industry collected in one convenient publication.

It is again urged that special attention be given to the question of standard methods and to the peculiar conditions under which samples must be taken in the gas industry.

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(The above is merely the introduction to the handbook. The complete book has not been printed in the PROCEEDINGS, for it is of interest to chemists only, and for working use, should be in pamphlet form. In this form, one copy can be procured, free of charge, by each member applying to the Secretary prior to July 1, 1915.)

THE CHAIRMAN: I think Mr. Fulweiler has presented the case in an interesting manner. If, as a result of the activities of the Chemical Section, we continually work on this Chemist's Handbook and keep it alive in the way he suggests, the uniformity of results which would follow uniformity of methods, in sampling, particularly, would justify a Chemical Section. All of us realize that what he has said about the fundamental importance of standard methods of sampling, is true.

I am going to ask Mr. Hinman if he will start this discussion on the proposed "Gas Chemist's Handbook," on which Mr. Fulweiler has done the first work.

MR. C. W. HINMAN (Winchester, Mass.): My work in gas testing, as most of you know, has been very largely official, but I have had some little experience as a gas chemist.

I want to commend Mr. Fulweiler very heartily for the work he has done here, and if I advance any suggestions, I hope he will understand it is not done in a spirit of adverse criticism.

MR. FULWEILER: Go as far as you like; that is what this meeting is for.

MR. HINMAN: In regard to sampling, there is where the chief differences between analyses come in. We should have some standard method of sampling the various substances.

In coal, for example, if you happen to get a little more pyrites, or pick out pieces without pyrites in them, your sulphur results will be a way off.

Now as regards the subjects to be included, I think it would be better at the outset to confine ourselves rather closely to the subjects Mr. Fulweiler has chosen, which are those of most importance to the gas chemist. For example, I see in the index "Analysis of asbestos;" that is all right, but a competent analytical chemist would know how to analyze that; also "Babbitt metal—analysis of," and things of that sort, which are not peculiar to gas manufacture.

If all these various substances were included, the book would be very much too large.

As regards methods,—for most, if not all, determinations, there should be more than one method given. If one method is more accurate than the others, and just as fast, that alone should be given.

When one method is accurate, but slow, and another is fast, and fairly accurate, both should be given.

Volumetric as well as gravimetric methods should be given, even if some of the solutions are troublesome to prepare; as they save much time if numerous determinations of the same substance are made.

In looking over the methods, I do not know that I can offer any great criticism. As far as I know, and as far as I have checked them off, the methods recommended are good.



My work has been largely in the exact volumetric analysis of gas, and the method recommended by Mr. Fulweiler is not what I have been accustomed to use.

The most valuable information given by eudiometric analysis, is the amount of nitrogen in the gas. It is very easily ascertained what those constituents are which are readily absorbable, such as oxygen, carbonic acid and the illuminants. Carbon monoxide is fairly simple, too. But the analysis is most valuable for nitrogen, and the method recommended by Mr. Fulweiler, although it is the one generally employed, is, to my mind, not as accurate as some others. In the given method, water is used and one-fourth to one-fifth of the residual gas from absorption is mixed with air and exploded. I use mercury and an explosion with oxygen. The explosion with oxygen as given in the books is that when you explode, a part of the nitrogen left in the residue will be oxidized to nitric acid, or nitrous acid. In the first explosion I make, I have an insufficient amount of oxygen for complete combustion, and it is pretty fair to assume that the nitrogen is much less easily burned than the hydrogen. After the first explosion, I draw in a second quantity of oxygen and explode again, and have the carbon dioxide formed by the first explosion as a diluent, so there is very little danger of oxidizing the nitrogen. I think by using all the residue, instead of a small part of it, that the error is reduced. Necessarily any error you make in determining that small portion, is multiplied by four or five according to the fraction taken. My method is given in Stone's "Gas Testing."

I do not say that this method given by Mr. Fulweiler is wrong, but that it is not as accurate as the method I have used for a good many years.

Another thing I noticed, was the determination of sulphuric acid, and that only the gravimetric method was used. The gravimetric method is all right, only there are several sources of error to be guarded against. Again, it is slow, and a chemist who has a large number of determinations to make,

must have a large number of crucibles. For years I have used another method, a volumetric method, which has been used by myself and other official chemists for some 30 or 40 years, and it has been pretty thoroughly proved, and is much more expeditious. Mr. Stone who has had much experience, states in "Practical Testing of Gas and Gas Meters" that you can make thirty or forty sulphuric acid determinations in a day; and I am quite in agreement with him. I know the method is quick, and I am sure it is accurate. I want to commend Mr. Fulweiler for his paper; I think he has made an excellent start.

THE CHAIRMAN: Mr. Tutwiler, have you anything to say?

MR. C. C. TUTWILER (Philadelphia): In spite of the adverse criticism of the handbook, made by Mr. Fulweiler himself, I have nothing but praise for it. One can but appreciate the large amount of work done in connection with its preparation, particularly so when the short time in which to complete the work at the disposal of the editor is taken into consideration.

While most of the methods presented are well known to most of us, some of them are distinctly novel. I think it highly desirable that the work should be continued from year to year and that sufficient publicity should be given to it to insure the final adoption of methods which will be generally approved. Some of the methods now presented will undoubtedly be criticised by those using other methods which local conditions seem to justify. It is therefore obvious that, in order to have a handbook of methods which will be generally approved and adopted by the industry, that all laboratories doing work of the kind represented in the handbook should be given an opportunity to present their methods to a committee or board of editors, who will finally select for adoption by the Institute the method which it desires to stamp with its approval.

As a concrete instance, we believe we are using in our own laboratory a method for testing oxide which is much to be pre-

ferred over the one given in the handbook. This method was developed too late to bring it to the attention of the editor. In this method, the hydrogen sulphide used is measured over mercury in a gas analyzing burette and passed, as in the method described, over a weighed quantity of oxide contained in a small glass tube. After each fouling, the amount of hydrogen sulphide is noted, the oxide revived, and the process repeated until there is no further absorption of hydrogen sulphide.

I think it probable that a number of the methods which we have long used and considered standard can be much improved upon and I, for one, hope very much that the work will be continued and that some means will be adopted whereby the best methods can be quickly ascertained and finally approved by the Institute. I think the Institute is to be congratulated upon the excellent start which has been made towards standardizing our methods of analysis.

THE CHAIRMAN: Has anyone else anything to say in regard to the Gas Chemist's Handbook?

MR. A. B. WAY (Everett, Mass.): The thing that impresses me very strongly in this handbook is the fact that Mr. Fulweiler has given so much gratuitous service in its compilation. I can see that a lot of work has been done.

I have not the temerity to criticise his methods, but I think that most of us have pet methods, and we have particular reasons for preferring our pet methods. It seems to me, therefore, that in the future work of such a committee, in the compilation of a handbook, there would be need of collecting the various methods used in different laboratories; and not only should copies of the methods be obtained, but we should seek to secure from the various chemists their reasons for their preference of one method over another. In that way the work would be simplified. With the opinions of different chemists before them and the reasons for such opinions, the committee will be in a better way to judge of just which methods should be stamped with the approval of the Institute. I

hardly like to make suggestions, but it strikes me that we should not confine ourselves to one method in each case. Alternate methods should be given with perhaps a preference expressed for a particular one.

I do not think I can add anything further except that I believe and feel that the Institute is very much indebted to the author for his arduous labors; and for the beginning of something which I believe will be a feather in our cap and a helpful guide to gas chemists.

THE CHAIRMAN: Mr. Uhlig, have you anything to say?

MR. E. C. UHLIG (Brooklyn): It is evident that Mr. Fulweiler has gone to a great deal of care and trouble in preparing this preliminary work on a handbook.

I would like to suggest to the future committee, that I do not agree with the last speaker as to recommending different methods. I think methods should be recommended only where there is a liability for dispute; and I think the Committee should also take into consideration rapid methods. There are many of us who have to work quickly, and while we know speed is desirable, we know that speed is sometimes gotten at the cost of accuracy.

Now the extraction method for oxides is accurate, as far as being able to remove from the oxide the amount of soluble sulphur; but that does not remove all of the sulphur. If you want to know how much sulphur your oxide has removed from the gas, it is my opinion that you should know all the sulphur present, whether it is available by a method of extraction or not.

Now, in regard to gas analysis, there are some of us who use methods of analysis which others think are not accurate, such as manipulation over water and explosion over water, but they serve their purpose, and they can be developed to some degree of accuracy, consistent with the speed required.

Has Mr. Fulweiler done any work on explosion of gas where air was used? I notice in all these instances given, oxygen is recommended; whereas I think, if the explosion

can be accomplished with air, air should be used, because air contains a constant percentage of oxygen.

I think Mr. Fulweiler well deserves the thanks of the Institute for this report, and I have no doubt it will be of great future benefit to us all.

THE CHAIRMAN: This being the first meeting of the Chemical Section, the chemists did not find their way here until 10 minutes after the time set for starting this session. Our time is up now for this particular subject. We are working on schedule, and must adhere to that schedule as closely as circumstances will permit. If there is anybody else having anything to say on this Gas Chemist's Handbook, we will be glad to hear from them now for one or two minutes.

MR. J. M. MOREHEAD (Chicago): Would it not be a good scheme if we were to get the Institute to go further than to recommend one method, and give certain methods for making these analyses and say "These are right." The electrical engineers have tests and abide by those tests.

There is no standard method for testing coke. We contract for coke under a certain fixed carbon determination. The people we buy it from make coke, and to them it is a finished product; with us it is a raw material. They have a method of testing and so do we. The methods give a different percentage. We tried testing it with their method, and we got their results. They tested with our method and they got our results, and there was no authority you could go to under those circumstances to say which method was correct. If you bid on their coke and their methods were standard, we would have made our specifications that way, and we would have been just as well off. As it was, we scrapped over the matter for months, delayed payments and referred it to other people, and they gave evasive answers.

Now, would it not be well for this Institute to get up certain standard methods of testing at this time. One man can go to work and make his method run up and down, and another can make his run down and up, and each says his method is

better than the other. I would like to propose to the proper authorities that this Institute get the methods by which we buy or sell supplies, and say "This is right." The gas analysis we do not buy by, and candle-power determination is pretty well standardized; but in coke and coal analysis, one man uses one method and another another, and there is no standard; and wherever payments are based on analysis, that question of difference of methods of test, will come out. And naturally, between two methods any analyst will use the one which shows up best for him. There should be one authority, and when you buy 100 or 1,000 tons, buy it according to the analysis set forth by the American Gas Institute, and then everybody knows what the conditions are, and how his product will analyze by that process. And then the man making the raw material and the man buying the finished product will meet on the same method.

I think the U. G. I. and the Consolidated would be willing to meet the Institute, and I speak for the Peoples Company of Chicago and say we would be glad to get some permanent method which would be standard, just as the Government has methods for testing standards. You buy cement now by "Paper No. 28." You buy electrical generators by the standard of the American Institute of Electrical Engineers. These big associations pick out a fair method and put the stamp of their approval on it, and it then becomes standard for that industry. We are the only people in authority to say what is right in regard to analysis of our supplies and products.

DR. A. H. ELLIOTT (Flushing, N. Y.): I want to endorse the sentiments of the last speaker. I do not know of anything more in need of standardizing than gas works methods of testing.

There is the American Chemical Society method for testing coal. It is used and quoted all over the world. I see that it is used and quoted in England and in Germany. Now, we can have standard methods in just the same way for testing gas oil and coke. I strongly endorse it, and that is the line of

work this handbook should be built on. Have a method which we endorse, which is the best to-day; and when anything new or important comes up, take out one method and put in a substitute. Have plenty of copies of it printed and distributed.

THE CHAIRMAN: I think Mr. Morehead and Dr. Elliott have expressed very emphatically the idea in the minds of the Committee on Chemical Program when they asked Mr. Fulweiler, to start this work, and I am sure if it is the wish of the Chemical Section, that this work shall be prosecuted vigorously in the future, as it seems to be, that the committee will bear these suggestions in mind.

We will now call on Mr. Fulweiler to close the discussion on this subject.

MR. FULWEILER: I am sorry I did not make myself clear on the question of standard methods at the start, but that is what this whole matter was gotten up for—in any case of dispute, the method herein prescribed was to be used.

I think it would be well, however, if we had an official standard method for purposes of dispute, and then some short quick method for routine control work.

I think that is quite proper, and, to get it into the record, I would suggest that for future committee work it would be an excellent idea if we circulated all the methods, and then organized the Chemical Section into a committee of the whole, and everybody try (say) oxide analysis for the first year; everybody having a pet method of analysis would send it in, and we would all test it on a standard sample, and report our results; and when we come to the meeting, we will have some actual and comparative figures to work on. If everyone has tried out all of the methods offered on the same standard sample, then you have something which will be absolutely convincing. I think this is the only way to reach the best method.

There are certain methods which we will have to accept as they stand, for instance, the report of the combined com-

mittee of the American Society for Testing Materials, and the American Chemical Society on the analysis of coal and coke. We cannot change these; we must accept them as they stand.

THE CHAIRMAN: One of the purposes of the section meeting, is to make definite recommendations to the incoming Technical Committee as to the work of our section for the future; and in order that this may be put in the form of a recommendation, I would be glad to entertain a motion to the effect that the incoming Technical Committee be requested to authorize the continuation of a committee in charge of the Gas Chemist's Handbook. Existing committees cease to exist at the close of this meeting. Making this definite recommendation to the new Technical Committee will probably result in their making provision to keep this work going.

MR. TUTWILER: I make such a motion.

MR. HINMAN: I second the motion.

THE CHAIRMAN: Is there any discussion? If not, those in favor will say aye (ayes); contrary (no response). It is unanimously carried that this work is to be undertaken through the Technical Committee and undoubtedly the Chemical Section will be called upon to do the work.

When you ask the Technical Committee to father this, you are asking for a job for yourselves; and I am sure the Technical Committee will be glad to set you to work.

#### APPOINTMENT OF SECTIONAL NOMINATING COMMITTEE.

One matter of business here is to get together and know one another as members of the Chemical Section. After this, it is our duty under the new Constitution, to select three members of this section, from one of whom the Committee on Nominations reporting to the 1915 meeting, must choose the candidate for vice-president, representing the Chemical Section. In order that this work may be put forward, I will ask Dr. A. H. Elliott, Mr. J. M. Morehead and Mr. W. H. Hinman to



be a committee to meet during lunch hour and select three names from the prospective membership of the Chemical Section, and report after the reading of the first paper this afternoon

Mr. A. B. Way, of Everett, Mass., will now present his paper entitled "A Method for the Determination of Hydrogen Sulphide in Gas."

#### A METHOD FOR THE DETERMINATION OF HYDROGEN SULPHIDE IN GAS.

There may be occasions in a large works when the quantity of gas made will vary to a considerable extent from hour to hour, and as the proportion of sulphuretted hydrogen extracted from gas by a partially fouled purifier depends largely on the speed of the gas, it is a difficult matter to determine the relative efficiency of a number of boxes unless the samples of gas are taken simultaneously.

To do this by the old methods where the gas was passed through some absorbing agent and metered would require a number of meters and absorbing trains. Besides the cost of apparatus for, say, a dozen samples, the setting up and running of the twelve determinations at one time would keep one man fairly busy for a while.

It was just such a contingency as this that impelled the writer to devise the method which is about to be explained in detail.

The apparatus used consists principally of a large, wide mouth bottle of about  $\frac{1}{2}$ -gallon capacity. The neck is fitted with a three hole rubber stopper which is marked in any convenient way by which one may be sure of its being inserted in the neck of the bottle to exactly the same point each time. Two glass tubes project through the stopper to a distance of about two inches above and to uneven distance below; one nearly to the bottom of the bottle and the other only a short distance below the stopper. A thermometer is fitted into

the third hole. Short, stout rubber tubes with pinch cocks are attached to the glass tubes. The bottle is calibrated at 60° F., including the tubes up to the pinch cocks.

The gas to be examined is passed through the *dry* bottle until all the air is expelled and the stop cocks are then closed, the outlet one first, which insures a pressure in the bottle.

The sample is brought to the laboratory and allowed to stand for a while until its temperature approaches that of the room.

One of the tubes is then connected with a longer rubber tube, the loose end of which is immersed in a beaker or other vessel holding exactly  $\frac{1}{4}$ -inch of water. The pinch cock on this tube is slowly released until the bubbles cease to rise through the water. The gas in the bottle may then be considered as being at normal pressure, for the pressure exerted by the  $\frac{1}{4}$ -inch seal amounts to only about 0.06 per cent. of the volume. The temperature is here noted.

After establishing normal pressure, the pinch cock is closed and the same tube is connected with a leveling bottle. The other tube is connected with a large burette containing an ammoniacal cadmium chloride solution (see foot note). By means of the leveling bottle a slight vacuum is produced in the sample bottle and about 30 cubic centimeters of the cadmium chloride solution are allowed to run in. The pinch cock is closed and the burette disconnected. The leveling bottle is raised, and at the same time the pinch cock is opened, and the gas which has been drawn out is forced back into the bottle. The leveling bottle is disconnected and the bottle containing the sample and cadmium chloride is shaken for a minute or two. Pressure is slowly released by opening the stop cock on the shorter tube, the stopper removed and the contents of the bottle poured onto a dry filter.

The bottle is rinsed three times with a little water without attempting to clean out the particles of cadmium sulphide which stick to the bottle and tubes; the precipitate on the filter is washed twice with water and the filter and precipitate are

placed in the bottle. An excess of  $1/20$  normal iodine solution, 3 cubic centimeters of starch solution, about 200 cubic centimeters of water and 50 cubic centimeters of commercial hydrochloric acid are added. The stopper is inserted, the pinch cocks closed and the bottle is shaken for a minute or two. The stopper is again removed, the tubes rinsed into the bottle and the excess iodine is titrated with  $1/20$  normal thiosulphate solution. By calculation from the calibration of the bottle and the absolute strength of the iodine solution, a factor is obtained which reads directly into grains of  $H_2S$  per 100 cubic feet of gas per cubic centimeter of iodine solution. A correction is made for the temperature and, if desired, for the pressure due to the  $1/4$ -inch seal. A blank is run every few days on the reagents used and the amount of iodine used in the blank is deducted from the iodine used in the determination.

The advantages of the method are that there is no action on the iodine by anything but  $H_2S$  as is the case when iodine is added directly to the gas, no meter is necessary and the number of determinations that can be made simultaneously is limited only by the number of calibrated bottles at hand.

The writer has taken twelve samples simultaneously from as many purifiers and finished the determinations on the whole set in less than two hours.

Duplicate determinations which check within  $1/2$  per cent. are of daily occurrence.

NOTE.—Ammoniacal cadmium chloride solution.

125 cc. water

20 grams cadmium chloride.

50 cc. strong ammonia.

Filter into bottle.

300 cc. strong ammonia.

Fill to 1 liter with water.

The following will serve as an example of the method of calculation.

A N/20 solution of iodine contains 6.346 grams of iodine per liter.

From the reaction  $\text{H}_2\text{S} + 2 \text{I} = 2 \text{HI} + \text{S}$ , 1 gram of iodine is equivalent to 0.13,428 gram of  $\text{H}_2\text{S}$ .

Therefore

1 cc. N/20 iodine solution = 0.00,085,214 gram or 0.01,315 grain of  $\text{H}_2\text{S}$ .

Then

$$\frac{\text{Cc. in 100 cu. ft.}}{\text{Cc. in bottle}} \times 0.01315 =$$

grain  $\text{H}_2\text{S}$  per 100 cubic feet per cc. N/20 iodine.

Assuming for instance that the bottle holds 2,000 cc. we have

$$\frac{2,831,677}{2,000} \times 0.01315 = 18.618$$

or

1 cc. iodine solution = 18.62 grains of  $\text{H}_2\text{S}$  per 100 cubic feet of gas.

MR. WAY: After the proof of this paper was sent to me, I handed it to one of my assistants. He came back to me and said "We will beat that all to pieces on time." He reminded me that when we were doing more of this work than we do now, he was accustomed to start in the morning at 7:30 with ten of these bottles in a large market basket. He would cross the plant and connect each bottle with a pet-cock, and after he had reached the last one, he went back to the first and collected the samples, brought them to the laboratory and let them stand; then he would go back for another ten, and when he returned, the temperature on the first lot had changed sufficiently for continuing the work. The first ten were then precipitated, and in turn, he would precipitate the second ten. Those twenty results were on my desk every morning by 9:30; so the work was better than I have reported here.

THE CHAIRMAN: You have heard a very interesting "pet method." Our neighbor's "pet methods" are sometimes very

objectionable to us. If there are any objections to this "pet method" we would be glad to hear them.

The paper is at your mercy, gentlemen.

MR. C. H. STONE (Middletown, N. Y.): At the time I was asked to discuss this paper, I did not know that I could be here, so I had prepared a memorandum which I will read.

The chemical principle on which this method is based is not a new one. Harding and Johnson last year described a process in which they absorbed the hydrogen sulphide in cadmium chloride, added hydrochloric acid and titrated the liberated hydrogen sulphide with iodine. They state that the whole operation takes but seven minutes, but I assume that this means for the actual chemical work and does not include gathering and preparing the sample. They agree with Mr. Way that it is much more accurate than the direct titration with iodine and indeed, in 1910 Ross and Race found that the direct titration was useless with water gas because of the presence of cyclopentadiene which causes quite an appreciable absorption of iodine in gases free from hydrogen sulphide. It might also be said that I have found sulphur dioxide present in illuminating gas and Carpenter reports its presence in the exit gases from the Claus process, and of course this would vitiate the iodine titration. Somerville also mentions the necessity of making a correction for hydrocyanic acid if that be present. All of these obstacles are overcome in Mr. Way's method, and while the chemical part seems to be practically identical with Harding and Johnson's method, the apparatus used by the latter, strikes me as rather delicate and expensive, while Mr. Way's is especially well suited to use in gas works.

The method has been worked out so thoroughly that there seems to be little to criticise. I would like to ask if there is not some chance that the rubber stopper will become worn and not fit into the bottle to the same point. I would also like to ask if Mr. Way considers the cadmium chloride a better reagent for this purpose than the arsenious acid recommended by Sutton. And further, if a large number of determina-

tions are to be made, whether stannous chloride would not be a better titrating agent than thiosulphate. I used stannous chloride in acid solution for a number of years with great success. It was kept in an atmosphere of carbon dioxide and standardized each morning against potassium bichromate. It kept its strength well, was easy to standardize and gave a good end point. I ask these questions as one seeking information, and not as criticism, for I think we will all agree that Mr. Way has furnished us with an excellent method, and I, for one, am glad of this opportunity to congratulate him.

THE CHAIRMAN: Apparently this pet method of Mr. Way's brings out another. Mr. Harper!

MR. R. B. HARPER (Chicago): He says he corrects for temperature; does the author correct for pressure?

MR. WAY: That was a slip or omission. All gas volumes must be corrected for pressure as well as for temperature.

MR. C. C. TUTWILER (Philadelphia): Could Mr. Way give any figures as to a comparative cost between this method and the direct titration method? For a number of years we have used this direct titration method. We knew it was not accurate, but we thought if the percentage of errors were carefully watched, that it would be practically negligible.

I haven't any figures to show what the direct titration method and the method Mr. Way suggests would show by way of comparison. If anybody has the figures, I would be glad to hear them.

DR. J. F. WING (Everett, Mass.): I have tried that method of Mr. Way's. Mr. Way spoke of a pet method. I have one of my own. I am able to confirm the relative accuracy of Mr. Way's method by several comparisons with the arsenic method, and also with my pet method. In a high sulphur gas containing about 1,000 grains of sulphur, the agreements are as close as 10 to 12 grains.

The other method referred to, consists in passing one-tenth of a foot of gas through double normal caustic soda, and a wet meter, adding an excess of boric chloride for the carbonate;

then neutralizing to a colorless state, with normal hydrochloric acid and phenol-phthalein; then titrating with iodine.

I think his use of cadmium is a complication. In the matter of speed, I favor this method, but correction for temperature must be made.

THE CHAIRMAN: I am glad one pet method brings out another, and I hope Dr. Wing will describe his method in full, and send it in.

MR. E. C. UHLIG (Brooklyn): I would ask Mr. Tutwiler about direct iodine titration. We have heard it does not work with water gas. In the case of water gas, a preliminary blank may be obtained by passing a purified gas, and making a direct iodine titration; and this applied as a correction to an unpurified gas. I am told this gives reasonably accurate results. Can that be verified?

MR. TUTWILER: Although I designed the apparatus some 15 years ago, I have added a great deal within the last 15 minutes, to my stock of information in reference to its possibilities and limitations. The apparatus has never been looked upon by us as giving scientifically accurate results, its usefulness being dependent, in our opinion, upon the rapidity with which determinations could be made and the fact that the error amounted to not more than one or two per cent. This is negligible when tests are being made to determine the efficiency of purifiers; *e. g.*, if the inlet of the purifier shows 300 grains of hydrogen sulphide per 100 cu. ft. and the outlet 100 grains, it makes little practical difference whether these figures are correct within three or four grains. We have always felt that the apparatus is correct within this limit of two or three per cent. I personally would like very much to see the result of comparative tests between the two methods.

MR. HARPER: We make a very rich gas in Chicago, and we find that an absolutely purified gas, that is purified from hydrogen sulphide, tested with the Tutwiler apparatus will show an error of about three grains.

MR. TUTWILER: That might have been due to the fact that

a certain small amount of iodine is used up, even if you are operating on pure air; a correction factor is therefore required. This factor is equivalent to one or two grains.

MR. UHLIG: Is not some of the iodine taken up by the unsaturated hydrocarbons in the gas?

DR. A. H. ELLIOTT (Flushing, N. Y.): If you look in the *Journal of the London Chemical Society* for the year 1869, you will find I used this method for determining sulphur in cast iron; and I did it then as I would do it now; that is to say, I used pure chemicals. It is perfectly simple if you take pure caustic sodium hydroxide. And it is perfectly feasible to pass the gas through that, and have a solution of sodium sulphide in there which you dilute to a large volume. I think it contains 0.05 or less than 0.05 gram of sulphureted hydrogen in the liter.

If you take pure sodium hydroxide, made from metallic sodium, dilute at once to a volume of about one liter, with water free from air—good distilled water is free from air—then acidify with chemically pure hydrochloric acid, you can titrate and get your results with iodine. That is so accurate it has been used since many years for determining the sulphur in iron and steel.

Now, it is not at all necessary to use cadmium chloride if you use pure chemicals; but if you do not use pure sodium hydroxide, you will get into trouble, as ordinary sodium hydroxide has a content which uses up the iodine. In gas we have a little difficulty (but that can be overcome) in the fact that the unsaturated hydrocarbons have an effect which you can counteract. When you are using the hydrogen sulphide solution in a given volume (and all of these must be done in uniform volumes), you must dilute your sodium solution, and get a definite volume of starch, and chemically pure hydrochloric acid in it. As soon as your iodine begins to give a blue color, it takes a little excess of the iodine, but as soon as there is a little coloring matter formed in the solution, giving a blue green, it must be stopped; and then it is extremely accurate.



It is to-day used in many iron works for determining the sulphur in iron and steel. The iron is dissolved and the hydrogen sulphide is evolved with the other gases, and passed into sodium hydroxide.

I mention that to corroborate Mr. Way's method. It is perfectly accurate and more so than anything else I know.

THE CHAIRMAN: I do not like to get off from the discussion of Mr. Way's paper if there is anyone else who wishes to make remarks on it. If there is not, we will call on Mr. Way for anything he has to say in closing the discussion.

MR. WAY: Of course the rubber stoppers do wear. The gas being put into these bottles under pressure, the stopper must be fitted rather strongly, and it will harden so that after a little while it must be pushed in tighter to make it fit snugly, but it is easy to calibrate to a new mark on the stopper.

As to the other chemicals to be used, Dr. Elliott has covered that point. This was not given as something new. I spent several years in a steel works laboratory; and that is where I got the idea of the titration of hydrogen sulphide with iodine, which Dr. Elliott speaks of.

In comparison with other methods, I think Dr. Wing has practically answered Mr. Tutwiler's question on that. We have tried it by two or three methods on simultaneous sampling, and when we were handling gas of 1,600 grains of hydrogen sulphide per 100 ft., we were getting then, by two or three different methods, a variation of 10 grains, or something like that in our determination.

Dr. Wing said he was on the other side of the fence from me. I do not care to state, therefore, as to which of these is the accurate one and which is the speedy one. The doctor said he used a wet meter. I would suggest if he has enough men to carry these meters around, that his method has some degree of speed.

MR. R. S. MCBRIDE (Washington, D. C.): (Communicated for the Bureau of Standards after the close of meeting.) We do not wish to appear to unduly criticise this article since most

of the points of which we make mention are not of serious consequence, but knowing the desire of the Institute to have all of the methods contained in these proceedings of a standard nature, we thought the suggestions below might be of interest:

The apparatus for collecting the sample could be made more accurate and still be equally convenient if a narrow-mouth bottle were used instead of the wide-mouth bottle recommended. This is desirable in order to reduce the variation in the volume of the bottle incident to inserting the stopper to different points. Although the neck of the bottle may be marked as suggested, it is, of course, impossible to exactly adjust the stopper, and the discrepancy will be least if the neck be narrow.

It might also be of advantage to have glass stop cocks on the inlet and outlet tubes, since this would prevent any variation in volume due to displacement of pinch cocks on rubber tubes. Of course, a glass stop cock would also reduce the likelihood of leakage.

On the second line of page 165 it is stated that the bottle including the tubes up to the pinch cock is calibrated at 60° F. It should be noted that the temperature at which calibration is made, is a minor matter. Would it not be well to indicate the method of calibration by stating somewhat as follows? "The bottle is calibrated by weighing it when empty and when filled completely with distilled water, determination of the capacity being made by calculation from tables showing the weight of 1 cc. of water at the temperature used in calibration."

In describing the taking of the sample, it is stated that filling the bottle under slight pressures "insures a pressure in the bottle." However, if the laboratory is cooler than the place where the sample is taken, the procedure described might not provide enough gas to give an excess of pressure above atmospheric at the time of the adjustment of the quantity of gas in the bottle. Furthermore, the method described permits considerable uncertainty as to when the temperature of the sample has reached room temperature. For these reasons, we

have felt that a variation of procedure might be desirable. The modified procedure would be as follows: "After filling the bottle by streaming the gas through it as described, close the stop cocks, the inlet one first, thus enclosing the gas at exactly atmospheric pressure and at the temperature of the bottle. The temperature indicated by the thermometer in the bottle and the barometric pressure at the time of taking the sample should be noted as the conditions under which the gas is measured, correction being made to standard conditions (60° F. and 30 in. of mercury) if desired." This procedure would eliminate the variation due to changes in atmospheric pressure which should be taken into account for any accurate work, but which are not taken into account by the procedure given in the original article. It eliminates uncertainties as to temperature in the bottle and does away with correction for the  $\frac{1}{4}$  in. seal referred to.

It is probably unnecessary to go through the rather complicated procedure of taking out some of the gas in order to introduce the cadmium chloride solution. The solution can easily be introduced from a leveling bottle connected to one of the gas tubes by elevating the leveling bottle sufficiently to overcome the resistance of the gas to compression. To introduce 30 cc. of solution in a bottle of 2,000 cc. capacity would require the leveling bottle to be raised only a few inches. This procedure would probably be better, since removing some of the gas and returning it gives considerable opportunity for leakage of gas and contamination of the sample.

The use of ammoniacal cadmium chloride solution is undesirable since it would make the results obtained too high. The ammoniacal solution reacts not only with hydrogen sulphide but also with carbon bisulphide to form a thiocarbonate which in turn liberates hydrogen sulphide and effects the titration. A neutral solution of perhaps five per cent. strength would absorb all of the hydrogen sulphide and would be free from this objection. It is recommended, therefore, that a neutral cadmium chloride solution be prescribed.

In filtering the solution, it is not necessary to use a "dry filter." It would be best to use an asbestos filter since the asbestos would not be acted upon by the iodine during titration as is the case with a filter of paper. However, the objection to use of paper for the filter is not a serious one provided the filter paper is not allowed to come in contact with a strong iodine solution.

The use of commercial hydrochloric acid as prescribed is not permissible since it almost always contains iron in the ferric condition which would in effect act like iodine. If arsenic or free halogen were present, they also would cause irregularities. High grade acid should be used for this work as the errors caused by commercial grades might be considerable.

The directions for titration procedure demand some modification to prevent considerable irregularities in the results. Such irregularities might not be detected by making duplicate determinations, since by following the same procedure, uniform but inaccurate results might easily be obtained. The following procedure is suggested: To the precipitate in the bottle there are added in the order given 300 cc. of distilled water, 25 cc. 1:1 hydrochloric acid and a slight excess of 1/20 normal iodine solution. The contents of the bottle are mixed by shaking and the walls and the gas connection tubes rinsed down with distilled water. One-twentieth normal sodium thiosulphate solution is then added slowly with stirring until the yellow color due to the iodine has almost disappeared; then 3 cc. of fresh starch solution are added and the titration with thiosulphate continued until the blue color just disappears.

In the calculation as indicated above, correction should be made not only for temperature, but also for variation in barometric pressure since this latter factor may be considerable.

If desired to get only an approximate and more rapid test than above indicated, the filtration may be omitted and a blank test run using a sample of gas which is freed from hydrogen sulphide by bubbling it through a solution of copper sulphate or other suitable reagent. The amount of iodine consumed in

such blank test would correspond to that reacting with the unsaturated hydrocarbons and other substances which might be dissolved in the reagents. This amount would be subtracted from the amount consumed in the regular tests to correct for this action of the hydrocarbons.

The formula for preparing the neutral cadmium chloride solution would be very simple, merely 50 grams crystallized cadmium chloride in 950 cc. of water, this giving a solution five per cent. by weight of cadmium chloride with two molecules of water.

MR. WAY: (Rejoinder to Mr. McBride.) The Bureau of Standards has with its characteristic attention to minute detail, suggested certain alterations in this method, to make of it a means of determining the hydrogen sulphide in gas with a greater degree of refinement than was originally intended by me or than the exigencies of ordinary works practice demand.

Our problem was to devise a method whereby we could get the relative efficiency of twelve or more purifying boxes in the shortest possible time, with a degree of accuracy within five or ten grains per 100 cu. ft. No finer degree of accuracy was sought, nor would it be of any practical use.

The bottles in use have a neck capable of holding a No. 10 rubber stopper. This is not very large, though a narrower one would, I admit, lessen the discrepancy in measurement due to the wearing or hardening of the stopper. We have tried glass stop cocks, but with little success.

Given a \$2.00 man with twelve of these large bottles equipped with glass stop cocks to carry around the works and manipulate, the chances of retaining your stock of glass cocks are remote. We found also that the glass cocks would not stand cold weather. At a temperature not much below freezing the core of the glass cock will crack, and after having lost ten of these in one day and several more on succeeding days during a cold snap, the glass stop cocks were abandoned.

In speaking of the calibration, I, perhaps, did not make my

meaning clear. It is simply that the number of cubic centimeters of gas at 60° F. and 30 in. of mercury, that the bottle will hold, is determined by calibration. As a matter of fact our procedure is exactly as the Bureau of Standards suggests.

Their modified procedure in taking the sample is a point that is well taken and I willingly accept the amendment.

It is perfectly true that it is unnecessary to draw out some of the gas in order to introduce the cadmium chloride, and in general we do not do so; but I have more than once seen a man trying to introduce 30 cc. of cadmium chloride solution into the bottle from a burette which contained only 30 cc. The result was that bubbles of gas came up from the bottle through the burette and escaped. For this reason I suggested the removal of a small quantity of the gas.

We have tried using a neutral solution of cadmium chloride, but found that one of the prime objects in using the method was defeated, in that the precipitation requires from three to five times as long to make as with the ammoniacal solution.

As to the action of carbon bisulphide on the ammoniacal cadmium chloride, our experience has seemed to show that this reaction requires considerable time. A bottle full of carbon bisulphide vapor into which ammoniacal cadmium chloride has been introduced will show no yellow until after the lapse of 15 minutes.

It is indeed unnecessary to use a dry filter, but time, the great object, is saved by doing so. Not only is the time which would be expended in fitting the filter saved, but the time of filtering is shorter, for the solution will certainly run through more quickly if a dry paper is used. The use of an asbestos filter would be under the circumstances a needless waste of both time and money.

If we were attempting to determine the hydrogen sulphide to the fraction of a grain, I would not recommend the use of commercial acid, but as the irregularities caused by the impurities in the acid can be no greater than the variations in

the hydrogen sulphide content of the gas that are momentarily occurring, it would seem like a needless expense to use high grade acid.

The modification in procedure in the titration is well put and is conducive to greater accuracy. As to the omission of the filtering process and titrating directly: This is not admissible when an ammoniacal solution is used, and as our experience seems to show that the neutral solution is too slow, filtration has become quite necessary.

I am glad that the Bureau of Standards has deemed it worth while to make these comments for it shows, I think, that a method which was designed only for speed and comparative approximations may be so modified as to make its use possible for exact determinations.

THE CHAIRMAN: The next paper is by Mr. F. W. Steere, of Detroit, on "An Electrical Process for Detarring Gas."

#### AN ELECTRICAL PROCESS FOR DETARRING GAS.

The object of this paper is to give a brief outline of the development of a commercial process for the precipitation of suspended particles from gas by high tension alternating current, and the practical application of this process to the removal of tar from coal gas and from producer gas.

As the early experiments with high tension discharges for precipitating suspended matter from gases have been reviewed quite thoroughly in recent articles by Prof. W. W. Strong, Dr. Cottrell and others, only a brief mention of them will be made here. The phenomenon seems to have been first discovered as early as 1825, but very little, if any, effort was made to make practical use of it. From the first the precipitation of smoke seems for the most part to have claimed the attention of experimenters. The possibilities of separating gold, silver and other metals carried in smelter fumes in a finely divided state, and the precipitation of acid fumes from smelters have also been fertile fields for inventors for years, the first patents having been issued as early as 1886.

The question is naturally asked why this method of purify-

ing gases has not long since been in commercial use. Possibly the answer is found in the fact that although the phenomenon may be readily demonstrated on a laboratory scale with very simple apparatus, many serious difficulties were encountered in the various attempts to develop commercial apparatus embodying the same principles, but capable of continuous operation with little attention. A beautiful demonstration may be given with a hand operated static machine discharging in a glass cylinder, or, on a larger scale, with an X-ray outfit discharging from wires suspended in ordinary piping, etc. Such work, however, is hardly the first step towards the solution of the problem of a complete installation doing service and earning dividends 365 days in the year under the conditions found for instance, in the ordinary gas plant.

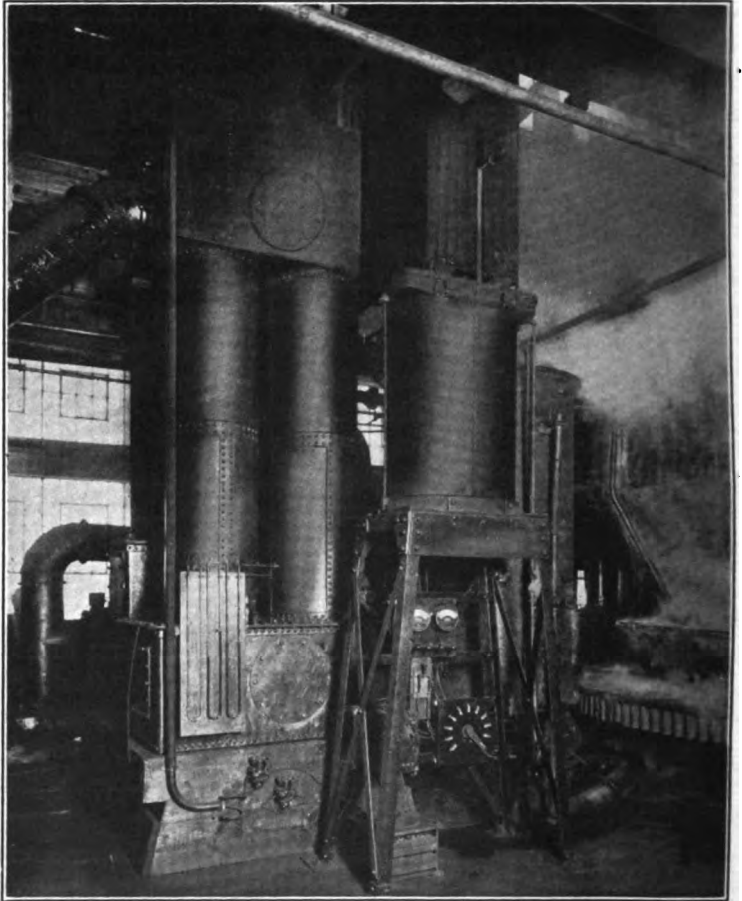
The process recently developed by Dr. Cottrell shows what can be accomplished in precipitating dust. The Cottrell process consists in rectifying high tension alternating current on rotating switches driven by synchronous motors, giving an intermittent unidirectional discharge. A plant using this process has recently been completed for precipitating the dust from the cement works of the Riverside Portland Cement Company, Crestmore, Cal., and according to recent reports is giving excellent results.

Herbert A. Humphrey seems to have been the first to use high tension electric discharges to precipitate tar. Prior to 1897 we learn that Mr. Humphrey was using a static discharge within a small glass vessel through which he passed a known volume of gas, for making quantitative determinations of the tarry matter carried by the gas.

In 1911 work was started along these lines in the research laboratories of the University of Michigan at the suggestion of Professor A. F. White. This work consisted for the most part in repeating the experiments of the early investigators and in attempting to apply the Cottrell process to the precipitation of tar from coal gas. The results of these preliminary investigations were given to the gas fraternity in a paper en-



titled "The Electrical Separation of Tar from Coal Gas," by A. F. White, J. W. Hacker, F. W. Steere, which appears in the Proceedings of the Michigan Gas Association for 1912.



**Electrical Detarring Process in Operation at the Ford Motor Company,  
Detroit, Michigan.**

The author while engaged in this research work at the University of Michigan became convinced that with a suitable ar-

rangement of electrodes and apparatus, alternating current might be used instead of rectified current. The complications and difficulties of rectifying alternating current of from 40,000 to 80,000 volts on synchronous motor driven rotating switches will be readily appreciated. No gas man would relish the idea of having such an outfit as a part of his plant equipment to be looked after by the average operator, especially in those states having Workmen's Compensation Laws. By the use of alternating current the synchronous motors and rotating switches would be eliminated as well as the leads carrying the high tension current from the transformer to the rectifier and from the rectifier to the electrode connections. Further, with the simple use of alternating current the transformer may be mounted on the ionizer, one terminal may be grounded and the other connected directly to the electrode terminal. With the terminals and connections completely enclosed so that no high tension parts would be exposed, and with no moving parts requiring attention or inspection, the element of danger would be absolutely eliminated.

An opportunity was provided at the Detroit plant of the Semet-Solvay Company to work out these ideas and develop the theory on which this work is based. This theory although far from complete, has proven sufficiently accurate to guide us in perfecting a detarring process which is in commercial use to-day.

In attempting to briefly outline the electrical action, we must keep in mind first that the gas molecules themselves possess both positive and negative electrical constituents which can be separated by X-rays, beta and gamma rays of radium, brush discharge from points, corona discharge from wires raised to high potential, ultra violet light, etc. This process of separating neutral gas molecules into electrically charged parts or ions is called "ionization." It is outside the scope of this paper to attempt to discuss the ionic theory, but it should be noted that ions as such are very unstable and cease to exist, that is, recombine to form neutral molecules, almost the in-

stant they are outside the ionizing influence. A very few molecules are continually splitting up, presumably because of the trace of radio-active substances found in most gases as well as in the atmosphere.

Prof. Millikan of the University of Chicago has studied the movements of a small drop of oil between two oppositely charged condenser plates when attacked by atmospheric ions.\* The drop receives a charge when atomized, so by throwing on and off the electrical field, the drop is made to beat up and down between the plates. The instant an ion attaches itself to the drop the fact is made known to the observer by its change in speed, this change depending on the sign of the ion and the charge on the drop. The important and interesting thing to note is that with over a thousand drops studied in this way, the change of speed was always exactly proportional to the number of ions attached to the drop.

Let us recall that there are about 27 billion molecules in one cubic centimeter of ordinary air and that each molecule may be separated into at least two ions. When just one of the possible 54 billions ions per cubic centimeter attached itself to the oil drop it instantly caused an appreciable change in its velocity. Imagine then the violence with which this drop would have been thrown about if all the molecules surrounding it had been ionized.

This is just the condition we bring about in the electrical detarrer. The gas carrying the minute tar globules is swept into an intense ionizing field. Billions of gas molecules on every side are being torn apart. The resulting ions rush madly about in their effort to recombine. The unsuspecting tar globules find themselves in a storm center of unseen forces hurling them in every direction. The time occupied in the passage of the tar particles through the electric field is brief and it might naturally be supposed, as it heretofore has been, that an aimless to and fro movement of them would be the result of the applied energy. It would, however, be hard to con-

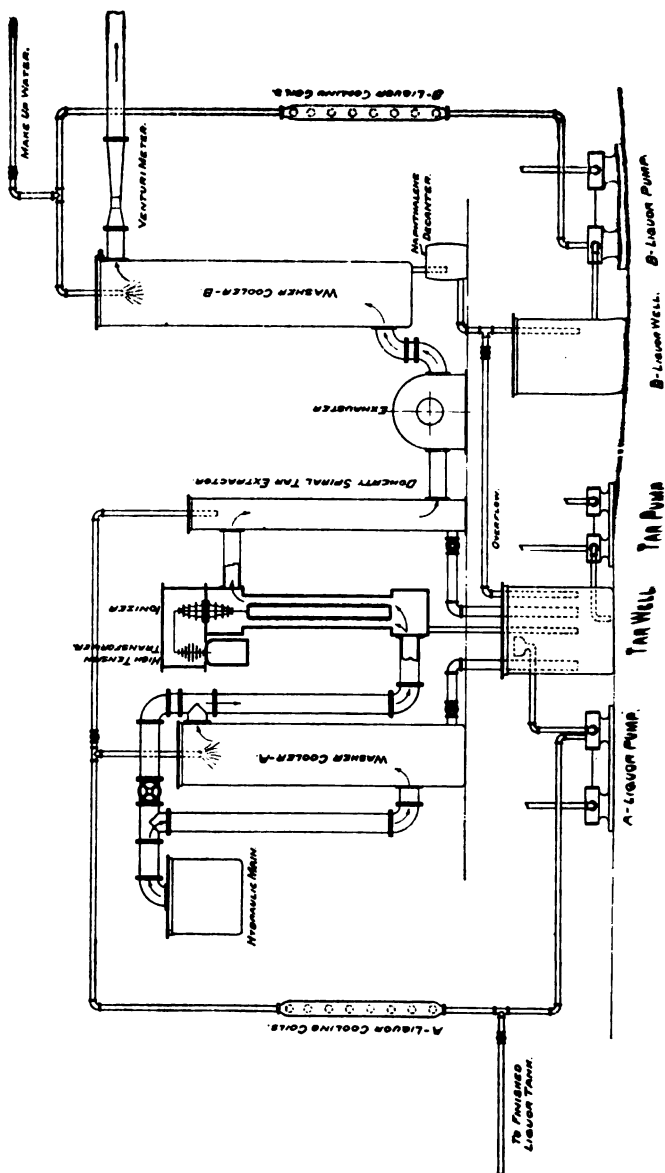
\* "The Oil Drop Method of Studying Electrical Phenomena in Gases," R. A. Millikan, *Trans. American Electrochemical Society*, Vol. XXI, 1912.

ceive of a condition more favorable to impact between tar particles, and experience shows that either because of this impact, or for some reason as yet unknown, agglomeration results and the dense tar mist is almost entirely dissipated leaving a relatively few large tar drops in its place. This rather figurative description will seem more real to those who have witnessed this remarkable phenomenon within a glass vessel filled with dense fumes or fog. The instant the current is turned on, the whole field can be seen to clarify. The commercial importance of this becomes more apparent when we realize that this action can be brought about at almost any desired temperature.

No attempt is made to free the gas of these agglomerated tar particles while it is still in the ionizing field. The apparatus is so arranged that everything is swept on through into some form of mechanical extractor where a complete removal is effected with very little power loss. The Doherty Centrifugal Tar Extractor worked very well to accomplish this; the old type P and A machine also became a very efficient tar extractor when placed after the ionizer.

The whole process may be summed up in this: It is practically impossible to free the gas from tar in the extremely fine state of subdivision which naturally results from rapid condensation. There is no difficulty in removing relatively large drops, and the electrical treatment simply converts the fine mist into the large drops.

A diagrammatic sketch of the experimental plant built at the Detroit Coke Ovens is shown in the accompanying cut. The plant was not built complete as shown here at first, but was added to and altered as the work progressed. The course of the gas may be readily seen by referring to the cut. From the hydraulic main the gas passed either to a small washer-cooler A or by-passed this directly to the ionizer, depending on the temperature desired for the test. After the ionizer came the mechanical extractor of which various types were tried. This apparatus was all on the suction side of the



DIAGRAMMATIC SKETCH OF THE EXPERIMENTAL PLANT FOR THE ELECTRICAL REFINING OF COKE OVEN GAS  
AT THE DETROIT PLANT OF THE SOMET SOLVAY CO.

motor driven exhauster. Following the exhauster was a second washer-cooler B, where the final cooling was effected. Measurements of the gas volume were made with a Venturi meter. The capacity of the plant was about 30,000 cubic feet of gas per hour. All work was done on the rich gas, that is, the gas given off during the first six or eight hours of the cooking period. To insure complete recovery of ammonia and in other respects to duplicate as far as possible the condensing system used at the Detroit coke oven plant, two sets of cooling coils were used, one for cooling the circulating liquor from washer-cooler A and from the mechanical extractor when liquor was circulated through it, and one set for the circulating liquor from washer-cooler B. The make up water was added to the B system and overflowed to the A system. When the A liquor was up to strength, it was pumped to the weak liquor storage tank.

Extensive use was made of the filter paper method of studying the condensed matter carried by the gas. This consists of aspirating a known quantity of gas through two thicknesses of filter paper, the resulting stain indicating relatively the quantity and to some extent the quality of the suspended matter. With the ordinary methods of condensing and cleaning, quantitative determinations by this method are unreliable, especially with producer gas, as an appreciable quantity of the very fine tar mist will pass readily through two thicknesses of filter paper. When the gas carries large quantities of tar mist, the aspirator bottle will be full of the dense brown fog which has passed through the papers. Over 1,200 of these tests were taken in the course of this work and although practically white papers were taken, we believe we have more reliable and conclusive evidence of the completeness of the detarring which will be mentioned later.

The best results were obtained with the gas entering the ionizer at a temperature of from 65° to 80° C. (149° to 176° F.). There was every indication, however, that with a gas not saturated with water vapor, the electrical action would

be fully as effective at very much higher temperatures. Since this action is purely electro-mechanical in so far as it affects the tar, the higher the temperature of ionization the more condensate will come down with the subsequent cooling. If the lower temperature condensates proved troublesome, a second treatment at a lower temperature could be used.

A very interesting development was the effect on the gas-man's old enemy, naphthalene. Naphthalene by itself in the gas works, is quite a harmless and possibly valuable by-product. The trouble is all in the company it keeps; when mixed with enough tar to act as a binder, it is exceedingly troublesome, but when the tar is removed before the naphthalene condenses in appreciable quantities, the real cause of the trouble is eliminated. This segregation was brought about as follows: Washer-cooler B was sealed in a barrel through a 3-inch pipe. The circulating liquor was drawn from the bottom of this barrel, cooled in pipe coils and returned to the top of the apparatus. It was found that with the foul gas entering the ionizer at about  $70^{\circ}$  C. ( $158^{\circ}$  F.) the naphthalene vapor was condensed in washer-cooler B, where the gas was cooled, and the crystals were carried out of the apparatus through the 3-inch pipe with the liquor into the seal barrel, and immediately came to the surface. The separation of the crystals and liquor even in this small vessel was almost perfect. After several weeks' run there was not the slightest indication of any deposit in the cooling coils or liquor lines. The gas was cooled in washer-cooler B to from  $16^{\circ}$  C. to  $25^{\circ}$  C. ( $60^{\circ}$  to  $77^{\circ}$  F.). Picric acid tests which were run to determine the naphthalene carried by the washed and cooled gas, checked invariably with the tables giving the theoretical naphthalene saturation at the observed temperature.

The whiteness of the naphthalene crystals recovered and the fact that there was absolutely no indication of any deposit in the coils or pipe lines, we consider proof conclusive of the complete freedom from tar.

Although at present naphthalene is a drug on the market it

possesses so many of the characteristics of an ideal fuel for certain power purposes we are confident that it will become an important factor when there is a sufficient and dependable supply available. The farm tractor seems to offer an attractive field for investigation along these lines, especially in view of the success with which naphthalene is being used as an internal combustion engine fuel abroad.

The two most valuable constituents of commercial light oil are benzol and toluol. The absorbing power of tar for these oils increases as the temperature decreases. With the tar as a fine mist the surface of contact between the tar and condensable hydrocarbon vapors is a maximum. It follows theoretically that if the tar mist is agglomerated to larger particles at relatively high temperatures the tendency for these oils to become absorbed by the tar is greatly reduced, and if this is followed immediately by a complete removal of the tar, this absorption of light oil by tar is reduced to a minimum. Considerable work was done along these lines which undoubtedly established this theory within the range of our observations. Unfortunately we were unable to get gas above 80° C. (176° F.) entering the ionizer, but analysis showed that the tar precipitated with the gas entering the ionizer at this temperature, contained but a trace of light oil, while the gas tested simultaneously, showed the highest light oil content. Light oil is, of course, not made by this process, but these experiments have shown beyond a reasonable doubt that the percentage of light oil carried by the gas and hence its illuminating power can be very materially increased. In coke oven practice this has a distinct commercial importance with the increasing value of benzol as a motor fuel, and of toluol, for use in the manufacture of explosives.

Cleaning producer gas for use in gas engines is one of the later developments of this process. Producer gas tar is very much more pitchy than coke oven tar and the tar mist particles hardened at very much higher temperature. The tar mist carried by this gas when rapidly condensed, as is necessary



in a compact plant, was found to be in such an extremely fine state of subdivision that a large per cent. of the tar passed readily through two thicknesses of filter paper. It is this extreme fineness and relative hardness of the tar particles which makes the complete cleaning of producer gas by purely mechanical means a physical impossibility without an excessive power loss.

Arrangements were made with the Ford Motor Company of Detroit to try this process on the producer gas driving their large gas engines. At the outset many unlooked for difficulties were encountered which required considerable time and study to overcome. Had it not been for the sportsmanlike attitude shown by Mr. Edward Gray, Chief Engineer and Designer of the engines, in giving us every opportunity to study out these problems, we might have a very different report to make at this time.

The electrical process was eventually put in run at the Ford plant the 21st of January, 1914, and up to this date has not been out of service one minute while the plant was running. All the difficulties which were in any way due to tar have been entirely eliminated. The regular operating force start up and stop the process with perfect confidence and at no time has it required any special attention.

In conclusion I wish to again call attention to the fact that this method of attack goes to the source of all the difficulties, that is, the almost molecular fineness of the tar particles which persist in carrying along with the gas in defiance of all mechanical scrubbers and washers. An enormous amount of time and study has been required to bring this process to its present stage, but notwithstanding the various difficulties, we now have in commercial operation a plant which requires no attention, is self-cleaning and is started or stopped at will by the regular operators.

The value of this electrical detarring process to the illuminating gas industry is as yet problematic, but it presents some very interesting possibilities. Its adoption would make possi-

le a somewhat higher illuminating power with a given gas than is obtained from the same gas when the tar is removed in the usual way. By its use followed by a washer-cooler, tar-free naphthalene can be condensed and removed from the gas without causing stoppages in the condensing apparatus. The tar can be completely removed from the gas at any desired point in the gas condensing and scrubbing system; the complete removal of tar, prior to condensing the gas, will make a relatively clean weak liquor possible. For the by-product coke oven industry the process promises to be of value in connection with the direct method for the manufacture of ammonium sulphate, as well as for its possibilities as a means for recovering naphthalene and increasing the yield of benzol and toluol. The commercial plant for detarring producer gas which has now been in continuous and successful service at the Ford Motor Company for several months has demonstrated beyond all doubt the value of the process for this branch of the industry. With these possibilities it seems not unlikely that this process may eventually play an important part not only in cleaning producer gas, but also in the manufacture of coal gas.

(Mr. Steere read an abstract of his paper.)

THE CHAIRMAN: Gentlemen, you have heard the first presentation before the Institute of an electrical process for the removal of tar from gas. This is probably the last time that the Chemical Section of the Institute will have a chance to do much with this. If the process should prove successful, I am very certain the gentlemen in the Manufacturing Section who have been inclined to reach out for everything they could possibly grab, will take this process bodily to their section. If it should prove to be of no value to the gas industry, possibly this will be the last time this, or any other, section of the Institute, will discuss it.

I have received a brief written discussion of this paper by Prof. A. H. White, of the University of Michigan, who, as

you all know, has had charge of the Gas Fellowship work at the University of Michigan, and it was while engaged on the Fellowship work, as Mr. Steere said in his paper, that his attention was drawn to this problem.

I am sure you will be glad to hear what he has to say.

PROF. A. H. WHITE (Ann Arbor, Mich.): (Written discussion communicated.) Mr. Steere deserves the greatest praise for the inventive ingenuity and care with which he has worked out his process. Starting as one of the collaborators in our application of the Cottrell process to the electrical precipitation of tar, whose further development has been recently described ("The Electrical Separation of Tar from Coal Gas," Second Paper, by A. H. White, R. B. Rowley, and C. K. Wirth, *Proceedings Michigan Gas Association*, 1914) he has succeeded in obtaining a similar result by novel methods. These two systems of tar precipitation differ in method, but give results which are, so far as can be seen, in complete agreement. It has been proven that all suspended particles can be removed from gas with small expenditure for installation and electric power. The process has been found to be effective for all temperatures at which it has been tried and offers fascinating possibilities. The tradition that gas must be cooled slowly and the tar removed at about 110° F. was the result of mechanical limitations in equipment and not of experiment which had shown that process to be superior. With the introduction of a process by which the tar can be removed at any desired temperature, better and more economical systems of condensation and purification become possible.

The higher the temperature of tar removal, the better should be the result, viewed from every standpoint. An electrical precipitation working at 175-200° F. will throw out a tar almost free from water which resembles some of the prepared tars in its properties. The gas should then be cooled rapidly and as cold as possible, preferably in a washer cooler. The faster the cooling, the greater will be the proportion of benzene remaining in the gas. Some naphthalene will probably crys-

allize out as white flakes which can easily be removed by a second electrical precipitation if necessary. The gas coming to the ammonia scrubbers will be clean so that white sulphate can be made directly if desired. The iron oxide purifiers will work more efficiently and have longer life, since they will not become fouled with tar. The purified gas will have higher heating value and candle-power.

The complete removal of all the tar at high temperatures will make it possible for the larger plants to economize space and cost of installation and to obtain better results than at present.

THE CHAIRMAN: Mr. Linn Bradley was also asked to discuss this paper. Mr. Bradley has been unavoidably detained, and he has asked Mr. Egbert to present his paper.

MR. LINN BRADLEY (New York): (Written discussion communicated.) The author states in the first paragraph that the process is "for the precipitation of suspended particles from gas by high tension alternating current," but he states further along (page 183) that "no attempt is made to free the gas of these agglomerated tar particles while it is still in the ionizing field. The apparatus is so arranged that everything is swept on through into some form of mechanical extractor where a complete removal is effected with very little power loss." It would seem from the statement therefore, that electrical precipitation, as generally understood, does not take place to any great degree, but that the tar particles are caused to build up from drops of extremely small size to relatively a few large particles, and that those well-known principles of removing particles from gases are employed which are based upon the increase in the ratio of the mass of the particle to the area which it exposes to the surrounding gas as the size of the liquid particle increases. This enables one to take advantage of the difference between the inertia of the moving particles and the force exerted upon them by the surrounding medium. Therefore any reagent which will form large particles from very small ones will be of prac-

tical assistance in efforts to free gases of suspended particles. As the author states, these phenomena have long been known. The author has described one method of accomplishing such a result by the use of high tension alternating current from a step-up transformer, followed by a mechanical tar extractor. Other methods have been proposed for causing the agglomeration of tar particles, and I understand that a process is now in commercial use on producer gas, being part of the producer equipment.

The author seems to consider that "the rectifying of alternating current of from 40,000 to 80,000 volts on synchronous motor driven rotating switches" would be complicated and difficult. Having had considerable experience with many installations of the Cottrell processes, in which this general arrangement is used, I must state that these features cause almost no concern in our actual practice. In fact, it is found that our most difficult problems are those concerned with the handling of the precipitated products, and the construction and arrangement of precipitating apparatus; the electrical apparatus has been quite well standardized and most of the efforts are now being directed toward standardization of electrodes, insulators, etc., connected with the precipitating treater itself.

It is very true that high tension current, whether alternating or direct, is not to be trusted to careless persons, and the safest way is to so enclose the apparatus that no one can come into contact with any parts of the high tension system. This has been done very successfully in the recent Cottrell installations.

Referring to the theoretical discussions by the author, the following statements may prove interesting:

Alternating current, as the author has stated, under certain conditions readily clears up a fog or cloud of finely divided particles. Probably it is chiefly due to agglomeration with subsequent deposition. But it is also well known that high tension direct current will readily precipitate particles of almost any nature if their size is within reason, and it is also known that

"discharge" electrode may, in some cases, be either negative or positive with respect to the opposed or "collecting" electrode, and yet obtain excellent and complete precipitation of the particles suspended in the gas.

Reasoning along these lines, one would be tempted to state that alternating current would accomplish the same results, since alternating current is merely a reversal of polarity at a frequency of so many cycles. Experiments were tried in order to observe the effect upon a cinder suspended by a silk thread in the electric field, using direct current in one set of tests and alternating current in another. With direct current, the "discharge" electrode, when made positive, would quickly drive the cinder to the collecting electrode, and the same result was obtained when the "discharge" electrode was made negative; but when the polarity was very rapidly reversed by using alternating current, the cinder remained almost stationary, thus showing the value of using essentially direct current in electrical precipitation work. The fact that the author has been able to make commercial use of alternating current followed by a mechanical extractor, shows that some gases can be freed of suspended particles by such a method, although in the major number of cases, direct current is by far the most useful agent. The author has drawn a very interesting mental picture for the purpose of describing what appears to be the reason that the agglomeration does take place when the gas is subjected to the influence of the electric field produced by alternating current. It would undoubtedly aid us in our investigations of such phenomena could we but obtain moving pictures of these suspended particles when under the influence of the electric field. Perhaps we should better be able to state exactly what transpires. Other feats, apparently even more difficult, have been performed, and I for one should welcome the attempt by some one to develop a method for attaining this end.

All of these investigations upon gases and the effect of electricity at high potential cause us to take particular interest in the dielectric strength of so-called insulating media, especially

air and other gases. In our work, we have encountered such peculiarities and conditions that we even hesitate to make use of the terms "static electricity" and "static charges." When one can cause the dissipation of several hundred or even thousand kilowatts of electrical energy between wires and pipes, the current actually flowing between a number of these electrodes in parallel, it would seem appropriate to term it "dynamic" in place of "static." When electrodes of this type are subjected to a high difference of electrical potential in a darkened room, the beautiful discharges may readily be seen. The term "corona" has been applied to such discharges. There is a very marked difference in the visual appearance of negative corona, positive corona and alternating corona. One can determine whether or not the "discharge" electrode is negative with respect to the "collecting" electrode by observing the corona in a darkened room. It has been observed that alternating current requires a greater amperage than direct current with either polarity. During the early work of Dr. F. G. Cottrell, when lower voltages were used than practice now requires, the "discharge" electrodes were mostly of the "pubescent" type, that is, fine hair-like filaments were used upon the discharge electrode surface in order to promote the flow of current between the electrodes. With higher voltages, these are not generally necessary. We have recently carried on some practical precipitation work by rectifying 150,000 volts alternating current by means of a mechanical rectifier, but this may not become universal very quickly, for difficulties naturally increase as the voltage is raised.

The author anticipates that by removing tar from gas by means of high tension electricity, a purer and whiter ammonium sulphate may be readily made, and, also, that naphthalene difficulties can be overcome. These advantages should be easily realized and they alone would seem to warrant the installation of the electrical precipitation processes. The possibility of removing tar at a fairly high temperature, in order that the higher volatiles or lighter oils might be retained and the illuminants thus increased, seems to have a

very practical application. This is analogous to work which we have been doing for quite some time in connection with various gases in other industries.

In conclusion, I would like to state that the author has rendered valuable service in conducting his experiments upon illuminating and similar gases, and that the gas industry should seriously consider the practical benefits that may now be obtained. Mr. Steere has, I notice, given proper credit to Prof. A. H. White, of the University of Michigan, for the original work upon this general problem, and I believe that credit should also be given to Mr. W. S. Blauvelt for the time and interest which he has given to this subject. I have discussed these problems with him on various occasions and found him enthusiastic and thoroughly interested in the practical outcome of the experiments which the author has so interestingly described.

THE CHAIRMAN: Is Mr. Kunberger present?

MR. A. F. KUNBERGER (Philadelphia): In reading Mr. Steere's paper, one can but feel that great progress has been made in purifying gas from tar. Since this process of removing finely divided particles suspended in a gas or gases has been successfully used in various industries, little doubt as to the ultimate successful application of the process in the gas industry can exist.

For the present, however, it should be ascertained whether or not the ionization has a bad effect on the illuminating gas (as now manufactured) as well as a corrosive effect on the holders and mains.

The first point confronting us is Mr. Steere's statement that the illuminating value of the gas does not suffer, which undoubtedly is true with all gases where the oily vapors are not the chief components of the illuminants.

It is ascribed to the fact that the tar extractor can be operated at a much higher temperature than commonly practiced. However, some doubt remains as to the effect on such gases where the light oil vapors form, to a large extent.



the illuminants. These vapors being ionized along with the tar are bound to be disturbed in the same manner as the latter and will therefore have the tendency to condense along with it.

I realize that the gas will be able to retain some of the benzol, etc., vapors, but by no means as much as if the particles had been undisturbed. This could perhaps be overlooked altogether, for the advantage of getting all the tar fog out of the gas and thus saving other operating expenses; and the illuminants thus removed could be passed back into the purified gas after separating them from the tar. A far more serious point confronting us in this process, is the ionization of the water vapor carried by the gas, which renders it corrosive, and the fixation of nitrogen with oxygen in the gas, etc.

Although the ammonia scrubber in the coal gas plant would take care of a great many of the corrosive elements thus formed, we nevertheless have just cause to believe that the gas having passed through the ionizer may have a bad effect on the holder and mains, particularly where no ammonia scrubber interfered, as is the case in the water gas plant.

MR. W. H. FULWEILER (Philadelphia): There are several points on which I should like to have further information if Mr. Steere is in a position to give it. What power is required in handling (say) 1,000,000 cu. ft. of gas per day?

Have any analyses been made of the recovered tar to show whether there has been any radical change in the character of the tar?

As I recall Prof. White's paper, considerable difficulty was encountered due to the breaking down of the insulation of the electrode. Have these been entirely overcome, so that the apparatus is now quite fool-proof, or does some further work have to be done to make it entirely practical?

What is the commercial status of the price at this time? Is it being sold as an apparatus outright, or on a royalty basis?

MR. J. W. BATTEN (Detroit): I think I can agree with

you, Mr. Chairman, that the manufacturing department is looking for the method of clearing up the difficulties which Mr. Steere has so well outlined in his method. I believe the elimination of tar at any desired temperature will absolutely revolutionize our methods of condensation. We have followed methods of condensation with the idea that tar was present through almost the entire condensation period.

I believe there are a large number of Cottrell installations where the insulation difficulties have been overcome. The University of Michigan had not sufficient preparation to take care of these difficulties.

The work initiated by Prof. A. H. White at the University of Michigan in 1911, looking to the electrical precipitation of tar from gas, has been carried to a successful conclusion by him and the holders of the Fellowship supported by the Michigan Gas Association. The work of Mr. Steere suggested by that done by him at the University of Michigan, has followed a parallel course, and its commercial continuous operation is the sure evidence of its success.

The work done by the University of Michigan and presented as a paper at the recent meeting of the Michigan Gas Association at Lake Harbor, describes the development of the application to coal gas of the pioneer work of Professor Cottrell. Direct current was employed with the necessary equipment of transformers, and rotating switches driven by synchronous motors. Insulation difficulties were the only ones seriously encountered during the final work. In this experimental plant, gas was treated at the rate of 30,000 cu. ft. per hour, giving evidence of success beyond the test-tube stage. So completely and satisfactorily have the investigations been carried forward that the Fellowship Committee of the Michigan Gas Association has considered that the final details for commercial application must be worked out in the plant itself, feeling that further work by the University would not be warranted by results that might reasonably be expected.

The desirability of obtaining a coal gas, water gas or coke

oven gas free from tar at any desired temperature, will determine the value of this work to our industry. The stoppage of washer coolers, tar washers and rotary scrubbers by mixture of tar and naphthalene is a subject too painful to dilate upon. A tar extractor capable of removing the last traces of tar has been hitherto unknown. This is particularly true of the tar fog produced by rapid condensation in washer cooler shells. Perfect removal of tar would undoubtedly eliminate such stoppages, as naphthalene would freely wash out without the presence of a binder. While Mr. Steere does not tell us the cost of operating the apparatus, the installation mentioned at the plant of the Ann Arbor Gas Company, where the Michigan Gas Association experiments were carried on, detarred 30,000 cu. ft. of gas at a cost of 230 watts, and I understand that the current cost is even less with alternating current apparatus as used by Mr. Steere.

The commercial value of pure naphthalene cannot at present be considered as a factor in determining the wisdom of any proposed installation, though the gain in light oils and consequently in candle-power, seems more than problematical. The absence of tarry oils in the purifying materials should undoubtedly increase its efficiency, while the ability to make sulphate direct would be of distinct advantage.

MR. T. HAIGHT (Brooklyn): I would like to ask if this apparatus is now in practical use in any water-gas plant?

THE CHAIRMAN: Is there any other question? If not, I will ask Mr. Steere to close the discussion.

MR. STEERE: In answering the question as to the effect of the electrical discharge on the illuminants in the gas: The electrical action may be thought of as electro-mechanical rather than electro-chemical in its effect on the gas as far as the tar is concerned. There is, therefore, no tendency to precipitate the condensible hydrocarbons held in vapor tension equilibrium. No effect on the quality of the gas was noted in the tests run. The same would apply to the effect on steel holders and mains. While no effect was noted during the

ests which only extended over about nine months, no trouble  
s anticipated from this source.

As to the question of power consumption: The power  
consumed by the electrical discharge is very small, the  
average consumption at the Ford plant being about 1.5 k. w.  
with the gas passing at the rate of 2,000 cu. ft. per minute.  
In addition to this, there is a loss of pressure through the  
mechanical separator following the ionizer which represents  
power absorbed. This loss depends on so many conditions  
and varies through such a wide range, that definite figures are  
misleading. In any case, however, the loss at this point is  
well within the range of good practice and does not militate  
against the practicability of the process.

As to the cost of apparatus: No two gas plants are just  
like. The result to be accomplished in a particular installa-  
tion as well as the local conditions surrounding it, have much  
to do with the cost of installing this process. We have been  
pleased to find, however, on several jobs we have figured on,  
that we can compete very successfully with the prevailing  
prices of the commercial types of tar extractors now on the  
market. The cost in any case is not prohibitive.

As to the effect on the tar: Analyses showed no other ef-  
fect on the tar than that the percentage of light oils was de-  
creased. This would follow from the theory outlined in the  
paper accounting for the increased candle-power of the gas  
after the ionizer, under certain conditions.

As to the problem of insulators: This problem has been  
absolutely solved. The Ford plant has now been running long  
enough to bring out any weakness along this line if it existed,  
and to date there has been no trouble whatever.

We have no plants operating on water gas.

In reply to the question as to how this work is being de-  
veloped: A company called the Steere Engineering Company  
with offices at Detroit has taken over the commercial process  
as well as the experimental work in the undeveloped fields.

THE CHAIRMAN: The next paper is "Tests of a New Recording Calorimeter" by Messrs. C. H. Stone, of Middletown, N. Y., and W. H. Hinman, of New York. This paper will be presented by Mr Stone.

## TESTS OF A NEW RECORDING CALORIMETER.

### INTRODUCTION.

The increasing use of the calorific test as a measure of the true value of gas to the consumer has rendered highly desirable the construction of an instrument which should give a continuous record of the thermal value. Such an instrument must be: (1) accurate within reasonable limits; (2) independent of fluctuations in gas pressure; (3) easily standardized; (4) as free as may be from complicated or breakable parts; (5) capable of registering gross or "observed" B. t. u.; (6) simple enough to be operated by men of moderate ability.

There are at present some 6 recording calorimeters on the market, *i. e.*, the Smith, the Simmance Abady, the Sarco, the Leskole, the Junkers and the Féry. Of these, only the Junkers, Simmance Abady and Sarco have received any degree of favorable notice in this country. The last two do not directly determine the heat units, and (at least in their original form) only the net value is obtained, while the Junkers has not seemed to prove satisfactory in places where it has been tried. It has appeared, therefore, as though there was room for another and more efficient recording calorimeter, and the American Meter Company has, for about a year, been experimenting in this direction, and has at last produced the instrument whose tests are to be described. It should be stated at once that this calorimeter is not as yet perfected, and various minor changes may be found desirable. We believed, however, that the principle was sound and, therefore, thought it best to publish the following tests, in order to apprise the gas fraternity of the progress being made, and to profit by the criticisms and discussion which we trust this paper will evoke.

## DESCRIPTION OF INSTRUMENT.

The instrument consists of a regular Hinman-Junkers calorimeter fitted with a pair of special recording thermometers and the usual meter, balance, glass thermometers, and governors before and after the meter. An overhead tank is required and under this the calorimeter is firmly mounted. Each recording thermometer consists of a tube about 10 in. long and  $\frac{3}{4}$  in. in diameter. These tubes are filled with mercury, and connect with the recording mechanism by means of a capillary tube. The change in volume of this mercury due to variation in temperature, causes a motion in an iron spiral similar to the motion produced in a spiral steam gauge by change in pressure. This motion is transferred by levers to a pen which records on a vertically moving chart driven by clock-work. As at present constructed, the difference between the lines of the inlet and outlet pens shows the rise in temperature of the water passing through the calorimeter; but it is hoped that eventually the chart will read direct in B. t. u. A continuous supply of water is necessary, and also, means of maintaining this at or near the temperature of the room. Tests can be made with this instrument exactly as with an ordinary flow calorimeter at the same time it is serving as a recording device.

## METHOD OF PROCEDURE.

In our tests, the instrument was mounted beneath a 60-gallon tank which was continuously supplied with water of the room temperature, obtained by means of a small gas water heater. The gas supply came through an independent line direct from the service, and had not been metered prior to reaching the testing outfit. This line was purged for at least 2 hours before each day's tests. The same meter and governors were used for all tests, and all connections were made with metallic hose. The plan was to run the instrument 7 hours a day for a period of 3 weeks. Each day a test was to be made at the beginning and end of the period with a Sargent calorimeter which had been standardized by the Public Service Commission, Second

District, New York. At least 3 tests were to be made during the day with the recording instrument, using it as a flow calorimeter, and these tests were to be compared with the chart obtained during the same period. On 6 days, complete tests were to be made every 15 minutes throughout the day, and the observations made in these tests will be shown in tabular form.

It seems hardly necessary to say that all of the precautions requisite for an accurate test were scrupulously observed. The usual procedure was to make a test with the Sargent calorimeter, then set the new instrument in operation and make a test with it as a flow calorimeter while the recording device was also working. In the middle of the day, a similar test was made on the recording calorimeter, and again at the end of the day, the latter being followed by two more tests with the Sargent calorimeter. On the 6 special days mentioned, the humidity, specific gravity and 'B. t. u. in condensation were also determined.

#### RESULTS OBTAINED.

It will at once be seen that 3 factors determine the success or failure of this instrument: (1) Constancy of gas rate; (2) uniformity of water rate; (3) accuracy of recording device.

For a considerable time, we experienced great difficulty in securing a constant gas rate. After investigating all other possible sources of trouble, the disturbing factor was finally located in the valve of the balance governor and in some slight irregularity in two of the wet meters tried. On substituting a new governor and a third meter, a gas rate was obtained which was constant within 1 per cent.

A uniform water rate should theoretically be much easier to secure than is a constant gas rate, and practically we found this to be true, provided all of the air in the water passages of the calorimeter were first expelled. This expulsion was accomplished by alternately closing and opening the quadrant cock on the inlet 10 or 12 times. The 60-gallon tank was provided





need of a *constant* water supply and the benefits of a tank of large capacity kept always full.

We had little or no trouble in maintaining the supply of water at, or very close to, the room temperature. A Doylair water heater was used, and after a little practice, this and the water supply could be so adjusted in 5 minutes as to maintain a very uniform temperature throughout the day. If the room temperature is liable to change 3 or 4 deg. during the day, the water can be supplied 1 or 2 deg. warmer than the room in the morning, and will thus never be more than 2 deg. in error; or in cases where it is convenient, the heater can be readjusted to correspond to the increase in room temperature.

The recording mechanism required practically no attention, save for filling the pens, winding the clock and setting chart, and while its accuracy will be discussed later, the device in general appears to be a success.

In the results which follow, we have plotted all of the B. t. u. figures obtained, and the chart (Fig. 1) is in large measure self-explanatory. It was thought best to start each day's plotting separately, and thus the line is broken at the end of the day. The upper or black line represents the result obtained by operating the instrument by hand and the lower or red line gives the results at exactly the same time, but taken from the chart. Where only two or three tests were made during the day, the points have been joined by dotted lines. While this may not be an ideal method of plotting, we believed that it would furnish the clearest idea as to the relation of the results obtained in the two ways. None of the results with the Sargent calorimeter were placed on this chart for three reasons: First, there were so few of them that it would not have left a fair impression; second, the recording calorimeter itself, when operated by hand, is fully as reliable a standard as the Sargent; and third, enough of the Sargent results will appear in a table to answer all purposes.

The chart (Fig. 2) shows the variations in water and gas rates for a period of 2 days. Lest there be some question as

to why we omitted the other days, it might be stated that it took us a number of days before we located the trouble with the gas rate and succeeded in making the same work properly; after this was once accomplished, however, there was such a sameness in the results that it was thought better to plot only

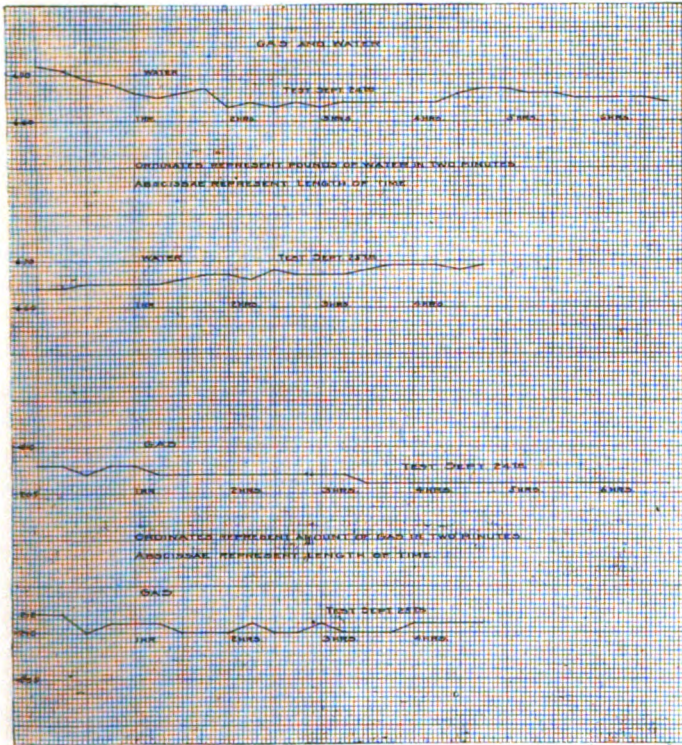


Fig. 2.—Variations in water and gas rates. Page 204.

2 days' figures, which are typical of the best we have been able to secure up to the present time.

The table (Fig. 3) which follows could have included all of the results obtained, but it would have been very bulky and no good purpose would have been served, so that it was thought

Time	Chart temperatures	Chart inlet	Chart outlet	Glass therm. inlet	Glass therm. outlet	Rise in temp. chart	Rise in temp. thermom.	Sec. for 2 revol. of meter hand	Lbs. water in 2 minutes	Temp. of gas	Temp. of exhaust	Temp. of room	Barometer	Pressure at meter, inches of water	Humidity per cent. by hygroscopic	Humidity per cent. by sling-bulb	Corrected gas in 2 minutes	Observed B. t. u. from chart	Observed B. t. u. from glass therm.	Dif. in B. t. u. of chart from glass therm.	Per cent. va- riation from glass therm.	Specific gravity
9.15	70.50	71.13	71.34	71.34	71.34	19.20	20.21	90.2	6.94	72.0	73.0	70.0	29.45	1.7	1.05	66	0.212	604	696†	-12	5.0	0.632
9.30	70.50	71.28	71.40	71.40	71.40	19.15	20.12	90.0	6.94	72.0	73.0	70.5	29.45	1.7	1.05	59	0.212	604	696†	-31	4.9	0.634
9.45	70.50	71.40	71.42	71.42	71.42	19.15	20.09	90.8	6.95	72.0	73.0	70.5	29.48	1.7	1.05	64	0.211	607	696	-29	4.6	0.630
10.00	70.50	71.40	71.42	71.42	71.42	19.15	20.02	90.4	6.95	72.0	73.0	70.5	29.48	1.7	1.05	64	0.211	607	696	-27	4.3	0.632
10.15	70.50	71.40	71.42	71.42	71.42	19.15	19.99	90.4	6.95	72.0	73.0	71.0	29.48	1.7	1.05	63	0.211	607	696	-26	4.1	0.632
10.30	70.50	71.40	71.42	71.42	71.42	19.15	19.85	90.8	6.95	72.0	73.0	71.0	29.48	1.7	1.05	63	0.211	607	696	-22	3.5	0.632
10.45	71.00	71.40	71.42	71.42	71.42	19.10	19.79	90.8	6.96	72.0	73.0	71.0	29.47	1.7	1.05	62	0.210	606	695†	-20	3.2	0.630
11.00	70.95	71.40	71.42	71.42	71.42	19.05	19.66	91.0	6.97	72.0	73.0	71.5	29.47	1.7	1.05	62	0.210	606	695†	-19	3.0	0.630
11.15	71.05	71.40	71.42	71.42	71.42	19.00	19.72	91.0	6.97	72.0	73.0	71.5	29.47	1.7	1.05	62	0.210	606	695†	-19	3.0	0.630
11.30	71.05	71.40	71.42	71.42	71.42	18.95	19.52	90.8	6.98	72.0	73.0	71.5	29.47	1.7	1.05	62	0.210	606	695†	-20	3.2	0.628
11.45	71.05	71.40	71.42	71.42	71.42	18.90	19.52	90.6	6.97	72.0	73.0	72.0	29.47	1.7	1.05	60	0.210	601	694	-21	3.1	0.628
12.00	71.05	71.40	71.42	71.42	71.42	18.80	19.48	90.6	6.97	72.0	73.0	72.0	29.47	1.7	1.05	59	0.211	597	698	-21	3.4	0.628
12.15	71.10	71.40	71.42	71.42	71.42	18.75	19.40	90.8	6.98	72.0	73.0	72.0	29.47	1.7	1.05	59	0.210	599	698	-19	3.1	0.627
12.30	71.10	71.40	71.42	71.42	71.42	18.75	19.39	90.8	6.99	72.0	73.0	72.0	29.47	1.7	1.05	59	0.210	599	698	-21	3.4	0.627
12.45	71.10	71.40	71.42	71.42	71.42	18.70	19.35	90.6	6.99	72.0	73.0	72.0	29.47	1.7	1.05	59	0.210	599	698	-21	3.4	0.627
1.00	71.10	71.40	71.42	71.42	71.42	18.70	19.35	90.6	6.99	72.0	73.0	72.0	29.47	1.7	1.05	59	0.210	599	698	-21	3.4	0.627
1.15	71.10	71.40	71.42	71.42	71.42	18.70	19.32	90.8	6.98	72.0	73.0	72.0	29.47	1.7	1.05	59	0.210	599	698	-20	3.2	0.627
1.30	71.10	71.40	71.42	71.42	71.42	18.65	19.31	90.4	6.99	72.0	73.0	72.0	29.47	1.7	1.05	59	0.210	599	698	-21	3.4	0.627
1.45	71.10	71.40	71.42	71.42	71.42	18.65	19.31	90.4	6.99	72.0	73.0	72.0	29.47	1.7	1.05	59	0.211	595	616	-21	3.4	0.626
2.00	71.10	71.40	71.42	71.42	71.42	18.50	19.27	90.6	6.97	72.0	73.0	72.0	29.47	1.7	1.05	59	0.211	590	615§	-25	4.1	0.626

\* Stem correction has been applied to these and each is the average of five readings.

† Test with Sargent calorimeter gave 640.

‡ Test with Sargent calorimeter gave 611.

§ B. t. u. in condensation, 45.3.

Fig. 3.—Table of sample day's tests. Page 205.

est here also to simply summarize one complete day's tests, and from this the general plan of the work, its thoroughness and the results obtained can be seen.

#### DISCUSSION OF RESULTS.

Taking up the 3 factors required for accuracy, let us first consider the water rate. By consulting the chart, Fig. 2, it will be seen that during a period of over 6 hours, the maximum variation was less than 1.4 per cent., while if the first hour's test be excluded, the maximum variation is about 0.6 per cent. When it is considered that an error of one-fifth of a second in switching the water made a difference of approximately 0.01 lb. in the 2-minute run, it is evident that a maximum variation of 0.04 lb. in 6 hours is not in any way excessive. In order to secure this degree of accuracy, it was found necessary to switch the water as the second hand passed the zero mark on the watch, and not to try to start the watch and switch the water at the same instant.

It also became apparent that the water rate must be determined at the beginning of each test, since after removing the air from the water passages, it would be impossible to reset the cock in exactly its original location.

In studying the curves for the gas rate, and again omitting the first hour, the maximum variation during the 6-hour period was 0.001 ft. or 0.5 per cent. Inasmuch as the smallest division on the dial of the meter which will be furnished with the recording calorimeter represents 0.001 cu. ft., it is evident that the above result is about as nearly correct as accuracy of observation will permit. This degree of accuracy can only be secured when both meter and governors are working perfectly. Practically the only factor whose influence on the gas rate has not been controlled, is the specific gravity of the gas, and if this is to vary greatly during the course of a test, it may be necessary to check the gas rate more frequently. This would be especially true in the case of a mixed gas where the percentages of the coal and water gas might vary greatly. In the case of straight coal gas or carbureted water gas, the errors

in any one day due to changes in specific gravity would probably be within the limits of error of the process.

Turning now to the chart of observed B. t. u., which in reality is a test of the accuracy of the recording thermometers and mechanism, it should be remembered that the true test of the satisfactory operation of the recording device lies in the uniformity of variation between the two lines on any one day. The reason for this is that the exit recording pen must be set each morning to agree with the reading of the exit water glass thermometer during a regular test. If this had been done in the tests shown on the chart, it will be seen that a very satisfactory uniformity in the two curves would have prevailed. The adjustment of the pen is very simply made by turning a thumb screw, so that no time or labor need be wasted in this operation. The chart furnished for our experiments was graduated from  $55^{\circ}$  to  $125^{\circ}$  F., and a space of about 0.1 in. represented 1 deg. It was thus not possible to read the chart closer than 0.1 deg., and as this equals from 3 to 4 B. t. u., depending on the rise in temperature of the water, this fact probably affected materially the showing made on the chart of observed B. t. u. In the chart which will be furnished with the instrument, this error will be reduced 50 per cent.

With regard to the table of sample day's tests, there seems to be no need of special comment, save possibly in the case of the humidity. This was taken both by a hygrodeik and a sling-psychrometer. The former was continually ventilated during tests by a slow current of air from an electric fan, while the latter was whirled and read in the usual manner. Distilled water was used on both instruments, and all calculations made from the same table, although the chart on the hygrodeik checked almost exactly with the table used. The thermometers on the two instruments were compared and found to agree. We call attention to the humidity results in the table simply as a matter of interest to those making humidity determinations, but no correction based on any of these results was made by us. Since the burner and air supply

are identical in the tests with the glass thermometers and recording thermometers, and since these tests were made at exactly the same time, the effect of humidity must have been exactly equal in both cases and so need not be considered. Likewise we made one or two determinations of B.t.u. in condensation, simply for the purpose of presenting a sheet of tests complete in all details.

The tests with the Sargent calorimeter were necessarily made at somewhat different times from the nearest corresponding tests on the recording instrument. They serve principally therefore to show the absence of any great error in either manipulation or apparatus.

#### CONCLUSION.

The results of the investigation may be summarized as follows:

1. The instrument should be allowed to run for an hour before tests are made.
2. Water rate must be determined each morning and should then remain constant within 0.6 per cent.
3. Gas rate must be determined each morning and should then remain constant within 0.5 per cent.
4. Recording thermometers must be set each morning to agree with glass thermometers and temperature interval should then remain correct within 1 per cent.

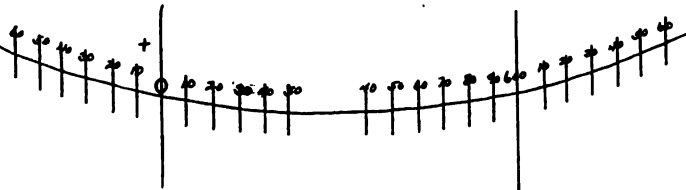


Fig. 4.—Proposed graduations for B. t. u. chart. Page 210.

As a result of the experience gained, we would suggest the following changes in the instrument:

1. The chart should be graduated vertically in 5-minute intervals, and horizontally from 550 to 650 B. t. u. in such a manner as to make it a direct reading chart. (See chart of proposed graduations, Fig. 4.)
2. Arrangements should be made for a more easy insertion and removal of the chart roll, and for care of the chart as it unrolls.
3. A finer adjustment on the gas cock at the burner.

With the above changes, we believe that an instrument will have been produced which, if used in the manner prescribed, will mark a distinct advance in the field of calorimetric work.

THE CHAIRMAN: Gentlemen, Mr. Stone's exceedingly interesting presentation of this subject is a reward for attendance. I must confess that his presentation of the subject from the floor was to me more interesting than my own reading of the paper. I think he deserves our thanks for presenting it so concisely. I believe a good recording calorimeter will fill a long felt want; this present want will become almost a necessity when we are compelled to operate on a much closer calorimetric basis than at present.

I will ask Dr. Elliott to start this discussion.

DR. A. H. ELLIOTT (Flushing, N. Y.): The experience I have had with a recording calorimeter was one we started at Tarrytown, and, as Mr. Stone said, our principal duty was in not relying too much on its automatic work. We worried too much on it, and for some reason, something got wrong with the water and the whole thing went up in smoke.

But, to come back to the instruments here, I do not think you can have anything that is much more carefully thought out. Personally, I do not take much stock in the refined corrections. That has been one of the things I have rather fought against in regard to calorimetric work generally. When you consider generally the variations of gases as made, and passing through any given main from hour to hour, I do not see the

need for so many fine corrections. Nevertheless, an instrument that would do that, is of tremendous use.

Now, with regard to this instrument Mr. Stone and Mr. Hinman have devised, it is very complete, and I do not doubt it would do the work they say it will do; and that we have got to have such an instrument in the future will be more and more apparent.

I think the day is right here now when coal will simply be considered uncivilized in our houses. I have already done much work on this line, and I think the coal-man and ash-man will be considered abominations in our homes; and if we use gas in large quantities, we must have a reliable method of calorimetric testing. This is an exceedingly practical instrument. The only other one I had any acquaintance with was one of the Junker type and not altogether accurate. It required someone to watch it, when it should be automatic.

I do not think I can add anything except to speak of the coming need of this instrument, which is obvious to anyone who has watched the development of gas. Talking to one of our engineers a while ago, I said: "I think we are going to heat our houses with gas;" he said: "That would take five or six times our present consumption;" I said: "Then you must build larger plants." With a standardized fuel, such as gas, we will know what we get much more perfectly than we know the value of a ton of coal.

MR. G. T. MACBETH (Mount Vernon, N. Y.): I would like to add one point about the calorimeter at Tarrytown, and that is, that we are fairly sure from the "remains" that our recording calorimeter took fire from the use of rubber tubing in making a joint.

MR. E. C. UHLIG (Brooklyn): Is there any difficulty in regulating the temperature of the inlet water, that is, does the tank which is recommended, fulfil that requirement totally?

Is there any difficulty about the recording instrument he uses? I have noticed in our works that such clocks can be slow or fast, and hard to regulate. And then, as some of us



have invested already in calorimeters, we would like to know, can we add this recording attachment to the calorimeters we now have?

MR. A. T. BALDWIN (Detroit): To discuss from a competitor's standpoint the paper that has been presented on the Hinman-Junker's Recording Calorimeter, is a rather delicate matter, but nevertheless I will endeavor to approach it in a fairminded and just way.

Recording calorimetry presents three questions. These are: What is to be the demand of a recording calorimeter? What must it automatically correct for if it is depended upon? For what service is it to be used and are users prepared for it? In what follows, I may answer some of these questions in answering the others.

As to the demand of a recording calorimeter, is it for the service of works' control or is it for the testing of the gas for official verification of its heating value? It has been definitely settled, I think, that the total heat value is the one to be determined by it. A large number of the states now have determined upon the total heating value as the standard, consequently for the determination of the heating value of the gas as delivered to the main from the works, this requirement must necessarily be fulfilled.

In discussing the calorimeter itself, naturally the first question entering the mind of anyone is "Is the calorimeter itself to be depended upon?" Both the American Gas Institute and the Bureau of Standards have reached the conclusion that it is. Nevertheless, there is a question that enters the determination of the heating value that I believe should be considered. If a calorimeter can be so designed that there is practically nothing to be corrected for or that would reduce the corrections to a minimum, surely that type of calorimeter would mark an advance over the one under discussion. I refer to the question of taking care of the varying moisture in the air automatically. I think that it can be proved conclusively that the flow type of calorimeter which does not take

care of this is thereby in error. The hydrogen containing gases produce condensate, some of which must pass off with the outlet gases from the calorimeter. For the simple reason that they pass away saturated and yet the air utilized for the calorimeter may enter it at varying per cents of moisture, by having the air enter a calorimeter practically saturated, this difficulty is overcome and if accuracy in determination is what is desired, then a calorimeter that would give this figure and take care of it automatically so that the calculation should not have to be made by the operator, would give the manufacturer a truer value of the gas that he is producing, than one not designed to accomplish this purpose. This has been the reason for the design of our total heat calorimeter. In this recording calorimeter of the American Meter Company, this has not been taken into consideration.

Secondly, the method of recording the temperatures of the inlet and outlet waters may allow for radiation error from these points of inlet and outlet that may or may not be of sufficient importance to consider. However, I do think it might be well to encase the outlet bulb of the calorimeter to overcome loss by radiation. Leaving the inlet bulb open to the air, would tend to equalize the temperature of the water with that of the room.

The third point would be the check of the recording temperatures. This can easily be done by inserting thermometers which have been carefully calibrated, in both the inlet and outlet bulb chambers and checking them up with the regular inlet and outlet thermometers. If a calorimeter is simply for works service only, correction for moisture and air might not have to be made. If it is for the determination of the heating value as delivered to the city mains, it might be very important to make these corrections, for naturally the gas maker wishes to obtain credit for all the heat in the gas and thereby overcome any possibility of a criticism from the Public Service Commissions.

As to the users being prepared for a recording calorimeter, I

would like to bring up a few points that we have met in introducing our own calorimeter, that might be of service to the American Meter Company in the development of theirs. I think the gas maker in purchasing the calorimeter, especially where the art has not been developed as fully as it might be, should have both the inclination and the determination to give the apparatus an absolutely fair treatment. I speak of this because we ourselves have met, I think, some rather unreasonable conditions which I do not believe justifiable. Although our calorimeter is supposed to correct for temperature, it is rather unreasonable to expect a recording device to take care of an instantly varying temperature that would result from opening a window near the calorimeter on a cold winter's day where the temperature within (say) would run 70, and without (say) 40.

Even though a calorimeter is designed to take care of varying temperatures within certain limits, nevertheless it would seem only fair and just to it to place it in a room where the temperature was practically under control and at least give it a room that is as suitable for it as for the flow type. The user should also be willing to deliver a water to it that as closely as possible is at a constant temperature, irrespective of the fact that the calorimeter may be designed to accomplish this same purpose. It might be well to filter the water to overcome the fouling of the interior of the calorimeter. The gases for delivery to the apparatus should be free from tarry matter so that the apparatus should not be fouled. This may be especially applicable to the service required of it. For works service, any filtering device for the gas should be of such a character as to deliver a clean gas to the apparatus and the gas maker for his own sake as well as that of the calorimeter manufacturer, should be willing to spend a little time in the development of such a filter, as he is fully informed of the character of the gas. In other words, do not subject the apparatus to unfair conditions. Let them be the best obtainable. Also in checking up the calorimeter, check it up with more than

one calorimeter. It is not impossible that the works calorimeter may be out of calibration.

We have a number of calorimeters in successful operation to-day, one at the Zenith Furnace Company, and a number of them elsewhere. A large number are in England.

In closing, I wish to say that I wish our competitors success in the development of an apparatus that will give to the gas public a means of greater control and better results than they now have, and a greater development of the art.

MR. STONE: I should be glad to claim the credit for devising this instrument, but I am only the assistant. Mr. W. H. Hinman is the technical man.

THE CHAIRMAN: If there is no further contribution, we will call on Mr. Hinman to close the discussion on this subject.

MR. HINMAN: Mr. Macbeth said that the calorimeter he had an experience with, burned out because of the failure of the rubber tubing. Our instrument would be furnished with metallic tubing throughout.

Mr. Uhlig brought out the question of inlet water. In winter the room temperature (say) is 70 degrees, the water coming from the main may be 40 degrees, or a little under. In that and many similar cases it would be necessary to supply the water through a small gas water heater. We did this in our test at Middletown, and we found that after setting the water heater and starting it, that it remained very constant throughout the day. We had no trouble with maintaining the water at or near the room temperature.

The recording thermometer is furnished to us by the Hohmann & Maurer Company. If it is borne in mind that this recording calorimeter is simply an ordinary calorimeter with recording thermometers, many of the questions would clear themselves, as all the factors and influences that will influence an ordinary calorimeter, have the same effect on this recording calorimeter.

The question was brought up of converting the calorimeters

now in use, and connecting them to the recording calorimeters. It would simply be necessary to add recording thermometers to the ordinary calorimeter.

Mr. Baldwin brought up a great many questions: First, the demand for such an instrument. We believe most gas men feel there is a great demand for a recording instrument. It would be of great service to a gas works engineer, or any one connected with the manufacture of gas, to note the variation of his B. t. u.'s during the day. As it is now, most companies make one test a day, some do not make more than two or three a week. Some make three or four a day, but the recording calorimeter will give a continuous result throughout the twenty-four hours, and enable the gas man to detect any variation. And we believe that the demand for that is very great. In fact if a satisfactory recording calorimeter can be furnished, most every gas company, I think, would get one.

It was asked whether it was for the works superintendent or the gas manager. I think I have answered that. It would be for both of them.

Before using the instrument for official tests, it would be necessary to have it officially inspected and approved. As Mr. Stone stated, we have just got this calorimeter to work, and this is really the first long test we have made of it.

We consider that there is practically no radiation from the tubes of the recording devices. The instrument is rejacketed throughout, and the tubes are likewise rejacketed.

As for various corrections of specific gravity and temperature, it would in some cases be necessary to make a correction, but that would be easily obtained by making an observation of the meter, getting the corrected volume, and applying that to the reading of the chart. That is, the first test would be to make a regular B. t. u. determination, and set the instrument. In that first determination, those correction factors are all present. Now, if those correction factors varied sometimes during the day, sufficiently to cause a correction for the instrument, the difference between the correction factors and the

first correction factors would give the basis for correction on the reading of the chart.

The room temperature—well, in reply to that I would say, as most people know, people are very careful of their room temperature. They do not open their windows to let a gale of air blow through. Everyone knows a calorimeter will not give the best results when a stream of cold air 30 or 40 degrees lower than the previously surrounding air is passed over it.

I do not know that filtering the gases is essential. It has been thought necessary for ordinary calorimetry work, and the same conditions should apply to the recording type of calorimeter.

Just to close: Mr. Stone spoke of the originator of the instrument. I might say that many of the men in the American Meter Company have been influential in devising it, and foremost among them is Mr. Harrington.

That is all. I thank you. (Applause.)

THE CHAIRMAN: I am sure we have had a very interesting and profitable first session of the Chemical Section. I have been agreeably disappointed in finding it was not difficult to fill our time entirely. There is one respect in which we have introduced efficiency in this session. Instead of someone getting up after each paper and suggesting a vote of thanks of the section for the author of each individual paper, this matter has been reserved until the close of the session, so that we can have one vote of thanks to include all of the authors of papers which have been presented this morning. I am now ready to receive a motion to that effect from Mr. Macbeth.

MR. MACBETH: I make such a motion, Mr. Chairman.

DR. ELLIOTT: I second the motion, and in doing it, I want to congratulate the Institute for giving the chemists a show. I say gas manufacture is essentially a chemical process, and all its ramifications are chemical. I appreciate the engineering end, but this is the American Gas Institute and not the In-

stitute of Gas Engineers. It comprehends everything in gas. (Motion stated and carried.)

THE CHAIRMAN: We started fifteen minutes late this morning. We must not be late in starting this afternoon. We have reason to be congratulated in that the Bureau of Mines has contributed so much to our program. This is a line of constructive governmental work which counts for a great deal. Each of us individually feels limited in the amount of research work possible for himself. It is an evidence of broad statesmanship that the government is taking up this research work, and it is encouraging to the men in the Bureau of Mines to go around to the different organizations, composed of men who can make use of knowledge which they secure in their investigations.

I think some action, possibly on the part of the Chemical Section, in the way of formal appreciation of that work of the Bureau of Mines, and also personal appreciation of the work of the gentlemen of that Bureau who have contributed to our work, would be in order this afternoon.

THE CHAIRMAN: We will now take a recess until 2 P. M.  
Adjourned, 12:35 P. M.

## CHEMICAL SECTION.

Afternoon Session, Thursday, October 22.

MR. W. S. BLAUVELT (Detroit), *Chairman*, Presiding.

MR. THEODORE BUNKER (Paterson, N. J.), *Section Secretary*.

The Chairman called the meeting to order at 2 P. M.

THE CHAIRMAN: We will begin the afternoon session by the presentation of a paper by Messrs. G. A. Burrell and I. W. Robertson, both of Pittsburgh, entitled "The Separation of the Illuminants in Mixed Coal and Water Gas." Mr. Burrell will present the paper. (Applause.)

### THE SEPARATION OF THE ILLUMINANTS IN MIXED COAL AND WATER GAS.<sup>1</sup>

#### INTRODUCTION.

In this paper are shown experiments made by the Bureau of Mines that resulted in separating the illuminants in the mixed artificial gas of Pittsburgh. This gas is made by mixing one part of carbureted water gas with three parts of coal gas. The separation was made fractionally distilling the gas in a vacuum at low temperatures and follows the method detailed by the bureau in separating natural gases.<sup>2</sup>

In both the natural gas work and the coal gas work advantage was taken of work on the subject by P. Lebeau and A. Damiens<sup>3</sup> who separated mixtures of the paraffin hydrocarbons, also artificial gas by the same method. The bureau, however, separated the paraffin hydrocarbons into single constituents and found it necessary to refractionate distillates and residues in all cases to obtain pure gases. Lebeau and Damien make no mention of this latter necessity and separated the paraffins in pairs. Further, there is shown in this paper

<sup>1</sup> Presented at the meeting of the American Gas Institute, October 20, 1914, New York City, with the permission of the Director of the U. S. Bureau of mines..

<sup>2</sup> Burrell, G. A. Seibert, F. M., Gas analysis by fractional distillation at low temperatures. Jour. of the Amer. Chem. Soc. Vol. 36 No. 7, July 1914, pp. 1538-1548.

<sup>3</sup> Comptes Rendus, Vol. 156, p. 325, 1913, and Vol. 156, p. 797, 1913.



a simple method for the determination of benzene in gas. The principle of the entire procedure rests on the fact that the gases at different stages in the analysis are subjected to temperatures at which certain constituents can be removed by a mercury pump from certain others which have low vapor tensions at the temperature selected. It was found impossible to make a clean separation in any case at one fractionation, hence distillates and residues were refractionated until the separation was as complete as was desired.

The following groups show the constituents in artificial gas that can be separated at different temperatures. The first column shows the distillates that can be obtained at a particular temperature and the second column the residues, *i. e.*, those gases that have inappreciable vapor pressures at the temperatures given.

#### TEMPERATURE OF LIQUID AIR

Distillates	Boiling point Degrees cent.	Residue	Degrees cent.
Methane ( $\text{CH}_4$ ) . . . . .	-160	Ethane ( $\text{C}_2\text{H}_6$ ) . . . . .	-93
Nitrogen ( $\text{N}_2$ ) . . . . .	-195	Propane ( $\text{C}_3\text{H}_8$ ) . . . . .	-45
Oxygen ( $\text{O}_2$ ) . . . . .	-173	N-Butane ( $\text{C}_4\text{H}_{10}$ ) . . . . .	1
Carbon monoxide ( $\text{CO}$ ) . . . . .	-193	Iso-Butane ( $\text{C}_4\text{H}_{10}$ ) . . . . .	-10
Hydrogen ( $\text{H}_2$ ) . . . . .	-253	Ethylene ( $\text{C}_2\text{H}_4$ ) . . . . .	-103
		Propylene ( $\text{C}_3\text{H}_6$ ) . . . . .	-51
		Iso-Butylene <sup>4</sup> ( $\text{C}_4\text{H}_8$ ) . . . . .	-4
		Benzene ( $\text{C}_6\text{H}_6$ ) . . . . .	80

#### -155° CENTIGRADE TO -145° CENTIGRADE.

Distillates	Boiling point degrees cent.	Residue	Boiling point degrees cent.
Ethylene ( $\text{C}_2\text{H}_4$ ) . . . . .	-103	Propane ( $\text{C}_3\text{H}_8$ ) . . . . .	-45
Ethane ( $\text{C}_2\text{H}_6$ ) . . . . .	-93	N-Butane ( $\text{C}_4\text{H}_{10}$ ) . . . . .	1
		Iso-Butane ( $\text{C}_4\text{H}_{10}$ ) . . . . .	-10
		Propylene ( $\text{C}_3\text{H}_6$ ) . . . . .	-51
		Iso-Butylene ( $\text{C}_4\text{H}_8$ ) . . . . .	-4
		Benzene ( $\text{C}_6\text{H}_6$ ) . . . . .	80

#### -130° CENTIGRADE TO -120° CENTIGRADE.

Distillates	Boiling point degrees cent.	Residue	Boiling point degrees cent.
Propane ( $\text{C}_3\text{H}_8$ ) . . . . .	-45	N-Butane ( $\text{C}_4\text{H}_{10}$ ) . . . . .	1
Propylene ( $\text{C}_3\text{H}_6$ ) . . . . .	-51	Iso-Butane ( $\text{C}_4\text{H}_{10}$ ) . . . . .	-10
		Iso-Butylene ( $\text{C}_4\text{H}_8$ ) . . . . .	-4
		Benzene ( $\text{C}_6\text{H}_6$ ) . . . . .	80

<sup>4</sup> The boiling point of N-butylene could not be found in the literature. The N-butylene was not separated from the iso-butylene. Neither was the N-butane separated from the iso-butane.

## -78° CENTIGRADE.

Distillates	Boiling point degrees cent.	Residue	Boiling point degrees cent.
N-Butane ( $C_4H_{10}$ )	1	Benzene	80
Iso-Butane ( $C_4H_{10}$ )	-10		
Iso-Butylene ( $C_4H_8$ )	-4		

COMPOSITION OF THE COAL GAS OF PITTSBURGH  
AS ANALYZED BY ORDINARY METHOD.

*Analysis made September 1, 1914.*

Constituents	Per cent.
Carbon Dioxide ( $CO_2$ )	2.64
Oxygen ( $O_2$ )	0.81
Illuminants	8.67
Carbon Monoxide (CO)	13.34
Hydrogen ( $H_2$ )	37.04
Methane ( $CH_4$ )	30.96
Ethane ( $C_2H_6$ )	1.82
Nitrogen ( $H_2$ )	4.72
Total	100.00

In making the above analysis, the carbon dioxide was removed by the caustic potash solution, the oxygen by alkaline pyrogallate solution, the illuminants by fuming sulphuric acid, the hydrogen by absorption in colloidal palladium<sup>5</sup> solution, the methane and ethane by slow combustion and the nitrogen by difference.

The above gas was next subjected to fractional distillation at various low temperatures in the apparatus shown in Fig. 1. (Apparatus for the Liquefaction and Fractionation of Gases). At (a) is shown a Dewar flask to hold the refrigerant used in cooling the gases; (b) is the bulb in which the gases were cooled; (d) is a gas analysis burette and (c) another gas container for measuring the gases prior to cooling; (e) is a pressure gauge for registering pressures in the Töpler pump; (f) is a drying tube containing phosphorous pentoxide for removing the water vapor from the gases; (g), (h) and (i) are containers for trapping the gases over mercury as they

<sup>5</sup> See Burrell G. A. and Oberfell G. G. The absorption of hydrogen by colloidal palladium solution. Jour. of Ind. and Eng. Chemistry, Vol. 6, No. 8, Nov. 1914.





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re gauge which was of principal use in the benzene determination; (o), (n) and (m) are three-way stop-cocks. A counterpoise (p) attached to the mercury reservoir of the Döpler pump greatly facilitated the working of the pump.

#### FIRST SERIES OF FRACTIONATIONS.

In Fig. 2 are shown the various steps in the main separation of the gas.

The original volume of sample (2,048 cc.) was first freed of the carbon dioxide by passing it through caustic potash solution. Fifty-three cc. of carbon dioxide were removed, leaving 1,995 cc. The latter quantity of gas was then cooled in the bulb (b) (Fig. 1), (about 300 cc. at a time) at the temperature of liquid air. After the introduction of each 300 cc., pumping was started, and as much of the gas removed as possible. There resulted a distillate (a) and a residue (b). The distillate (a) was fractionated at the temperature of liquid air, resulting in two more fractions (c) and (d); (d) was added to the residue (b), and the total again fractionated at the temperature of liquid air. The distillate (f) thus obtained was added to the distillate (c), and the total again fractionated at the temperature of liquid air. The residue thus obtained (10 cc.) was added to the residue (e), and the total again fractionated. There resulted a distillate (g) of 3 cc. which was added to the distillate (i) making a total of 1,782 cc. This first series of fractionations shows the general procedure. At the temperature adopted—in this case the temperature of liquid air—the gases were repeatedly fractionated until no more distillate of consequence could be obtained. Three cc.—the final distillate obtained—is about only 0.15 per cent. of the original quantity of gas (2,048 cc.) taken for the experiment. The total distillate obtained at the temperature of liquid air was 1,782 cc., and consisted of those gases that have an appreciable vapor tension at that temperature. This fraction consisted of 0.81 per cent. oxygen, 13.25 per cent. carbon monoxide, 37.33 per cent. hydrogen, 31.13 per cent. methane, and 12.23 per cent. nitrogen. It will be observed that the quantities

of these constituents check very well with the quantities of the same constituents found in the original ordinary analysis of the coal gas (p. 3). The residue of the first series of fractionations (191.6 cc.) should consist of those gases and vapors that do not have an appreciable vapor pressure at the temperature of liquid air. They are  $C_2H_6$ ,  $C_3H_8$ ,  $C_4H_{10}$ ,  $C_2H_4$ ,  $C_3H_6$ ,  $C_4H_6$  and  $C_6H_6$ . In other words, the so-called illuminants of coal gas with the addition of ethane and probably propane.

#### SECOND SERIES OF FRACTIONATIONS.

The residue (h) (191.6 cc.) was next cooled at temperatures ranging from  $-155^\circ$  to  $-145^\circ$  C., and as much gas removed as possible with the mercury pump. Distillates and residues were repeatedly fractionated until there was obtained 167.0 cc. of gas consisting of ethane and ethylene. This fraction was analyzed in two ways, first by burning the entire fraction with oxygen and second by first removing the ethylene with fuming sulphuric acid and then burning the ethane in oxygen. The data covering these two methods of analysis follows:

#### ANALYSES OF ETHANE AND ETHYLENE.

##### ANALYSIS BY COMBUSTION.

	Cubic centimeters	Per cent.
Sample taken .....	15.12	—
Oxygen added .....	94.42	—
Total volume .....	109.54	—
Volume after burning .....	78.00	—
Contraction produced .....	31.54	—
Volume after KOH absorption .....	48.27	—
Carbon dioxide produced .....	29.73	—
Ethane .....	—	23.90
Ethylene .....	—	74.40

##### *Analysis by Absorption and Combustion.*

	Cubic centimeters	Per cent.
Sample taken .....	34.18	—
After absorption in fuming $H_2SO_4$ ..	8.85	—
Absorbed by fuming $H_2SO_4$ .....	25.33	—
Oxygen added .....	76.28	—
Total volume for combustion .....	85.13	—
Volume after burning .....	64.95	—
Contraction .....	20.18	—
Volume after KOH absorption .....	49.02	—
Carbon dioxide produced by burning ..	15.93	—
Ethane .....	—	23.3
Ethylene .....	—	74.1

It will be observed that the ethane and ethylene, as found by the two methods of analysis, check very well, showing that other gases were not present in the distillate in significant amounts. The percentages as found above were averaged and calculated to percentages of the original gas.

### THIRD SERIES OF FRACTIONATIONS.

After the removal of the ethane and ethylene, there remained 4 cc. of gas which was fractionated at temperatures ranging from  $-130^{\circ}$  to  $-120^{\circ}$  C. The distillate, 21.1 cc., was analyzed by burning it in oxygen, and measuring the resulting contraction and carbon dioxide and calculating to propane and propylene. This method does not isolate the gases, and hence does not show that other gases than these two were not present. Working on the separation of the paraffin hydrocarbons, however, the Bureau found that propane could be separated from ethane at temperatures between  $-130^{\circ}$  and  $-120^{\circ}$  C. Propylene has a boiling point very close to propane, and the boiling point of ethylene is not far different from that of ethane, hence it is assumed that propylene and ethylene would respond to the same treatment as the propane and ethane.

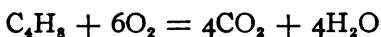
### FOURTH SERIES OF FRACTIONATIONS.

After removing the propylene and propane, there remained a residue of 2.3 cc., only 0.11 per cent. of the original quantity of gas (2,048.0 cc.). This residue was analyzed by burning in oxygen, and the contraction and carbon dioxide calculated to butylene. The observed data follows.

#### ANALYSIS OF BUTYLENE RESIDUE.

	Cubic centimeters	Per cent.
Volume taken for analysis.....	2.3	—
Oxygen added .....	93.81	—
Total volume .....	96.11	—
Volume after burning .....	90.53	—
Contraction produced .....	5.58	—
Volume after KOH absorption .....	82.86	—
Carbon dioxide produced by burning..	7.67	—

According to the reaction





there results 3 volumes contraction and 4 volumes carbon dioxide, when butylene reacts with oxygen. The contraction and carbon dioxide observed in the above analysis, 5.58 cc. and 7.67 cc., is almost in the ratio of 3 to 4, within the error of making the analysis, hence the data was calculated to butylene. Such a small quantity of gas was available to work upon that there might easily have been a trace of butane present. However, the total quantity compared to the original volume was only 0.11 per cent. or practically insignificant.

The total number of cubic centimeters of gas from the various fractions equals  $1,782 + 167 + 21.1 + 2.3 = 1,972.4$  cc. This is exclusive of the benzene. The benzene as found by using a separate portion of the gas is 1.33 per cent. of the gas. Then  $2,048 \text{ cc.} \times 1.33 \text{ per cent.} = 27.2 \text{ cc.}$ , and  $1,972.4 \text{ cc.} + 27.2 \text{ cc.} = 1,999.6 \text{ cc.}$ , or within about 5.0 cc. of the amount (1,995 cc.) that was fractionated. Considering the number of times the different fractions of gas were handled and measured in the fractionation analysis, this is not a bad check on the operation.

#### DETERMINATION OF BENZENE.

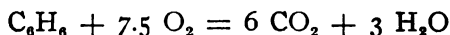
For the benzene determination, a separate quantity of gas was used, and advantage taken of an apparatus suggested by Dr. G. A. Hulett, Chief Chemist of this Bureau, for the determination of water vapor in air. Dr. Hulett suggested that air with its moisture be cooled at the temperature of liquid carbon dioxide and the air be then removed with a mercury pump, and the water vapor be determined after removing the cooling medium, by measuring its pressure. It was a simple matter to apply this principle to the determination of benzene in coal gas. The procedure was to free the coal gas of carbon dioxide and water vapor and introduce it into the liquefaction bulb (b) (Fig. 1), cool it at a temperature of  $-78^{\circ} \text{C.}$  and remove as much gas with the pump as possible. The stop-cock (n) on the bulb was then closed and the Dewar flask containing the cooling medium removed. The condensed liquid in the bulb was then vaporized and its pressure read on

the manometer (j) (Fig. 1). This pressure compared to the original pressure of the gas gave the per cent. of benzene in the coal gas. The results of two determinations are shown in the following table:

#### RESULTS OF THE BENZENE DETERMINATION.

Original pressure of the gas Mm. of mercury	Partial pressure of the benzene vapor. Mm. of mercury	Illuminants found in the distillate Per cent. of the total coal gas	Calculation of benzene	Per cent. benzene in the mixed gas of Pittsburgh
744	10	7.32	$\frac{10 \times 100}{744}$	1.34
744	9	7.39	$\frac{9 \times 100}{744}$	1.31

The total illuminants in the mixed gas of Pittsburgh as found by absorption in fuming sulphuric acid, is 8.67 per cent. (p. 11). The distillate from the benzene determination was analyzed by absorbing the remaining illuminants in fuming sulphuric acid. There was removed 7.32 and 7.39 per cent. of the distillates. These amounts, when added to the benzene, found 1.31 and 1.34 per cent. equal 8.66 and 8.70 per cent., or almost identical with the total illuminants in the mixed gas. Benzene reacts with oxygen as follows:



The contraction is 2.5 volumes and the carbon dioxide is 6 volumes. The following data shows the results of analysis of the residual vapor that was held in the liquefaction bulb (Fig. 1) when the gas was cooled at a temperature of  $-78^\circ \text{C}$ . before analysis, the benzene vapor was diluted with air.

#### ANALYSIS OF BENZENE VAPOR.

	Cubic centimeter
Volume taken for analysis .....	28.29
Oxygen added .....	51.94
Total volume .....	80.23
Volume after burning .....	75.47
Contraction due to burning .....	4.76
Volume after KOH absorption .....	64.25
Carbon dioxide produced by burning .....	11.42

It will be observed that the ratio between the carbon dioxide and contraction is almost exactly 6 to 2.5, showing that the vapor obtained in the determination was benzene. Traces of other easily condensable vapors may have been present, but apparently in such small quantity as to be negligible. The authors of this publication were unable to find the vapor pressure of benzene at  $-78^{\circ}$  C., but apparently it is very small. Benzene boils at  $80^{\circ}$  C. At  $-20^{\circ}$  C., the tension is 5.76 mm.<sup>6</sup> The authors prepared saturated vapors of benzene by shaking pure benzene with dry air. It was a simple matter to prepare unsaturated vapors of benzene by simply diluting the saturated vapors with air. The quantity of benzene in the air was checked by combustion analysis. A number of tests were made of the benzene in air by the method just described. It was found that at  $-78^{\circ}$  C. all of the benzene could be separated from the air. Analyses were made of the distillates and residues to make sure that all of the benzene remained in the liquefaction bulb at the temperature of  $-78^{\circ}$  C. The foregoing method, therefore, seems to be well adapted for the benzene determination. There is needed a mercury pump, a liquefaction bulb, a gas burette for introducing the gases and a Dewar flask for holding the refrigerant. A temperature of  $-78^{\circ}$  C. can easily be obtained by using the liquid carbonic acid sold in tanks. The original volume of gas does not even have to be measured and its exact volume determined. It is sufficient to introduce it into the liquefaction bulb at atmospheric pressure and then to read the barometer. The authors have also used this method for the determination of gasoline vapor and water vapor in air.

#### COMPLETE ANALYSIS OF THE MIXED ARTIFICIAL GAS OF PITTSBURGH.

The complete analysis of the coal gas as found by the foregoing methods follows:

<sup>6</sup> Landolt and Börnstein. *Physikalisch-Chemische Tabellen*, 1905, p. 143 (According to Regnault).

## COMPLETE ANALYSIS OF MIXED ARTIFICIAL GAS.

Constituent	Formula	Per cent.
Carbon dioxide	CO <sub>2</sub>	2.63
Oxygen	O <sub>2</sub>	0.80
Carbon monoxide	CO	13.25
Hydrogen	H <sub>2</sub>	37.33
Methane	CH <sub>4</sub>	31.13
Ethane	C <sub>2</sub> H <sub>6</sub>	2.10
Propane	C <sub>3</sub> H <sub>8</sub>	0.35
Ethylene	C <sub>2</sub> H <sub>4</sub>	6.05
Propylene	C <sub>3</sub> H <sub>6</sub>	0.60
Butylene	C <sub>4</sub> H <sub>8</sub>	0.11
Benzene	C <sub>6</sub> H <sub>6</sub>	1.33
Nitrogen	N <sub>2</sub>	4.32
Total		100.00

## ANALYSIS OF A DIFFERENT SAMPLE OF COAL GAS.

There is shown below, the analysis of a sample of the mixed gas of Pittsburgh collected at a different date than the one already given. It is interesting as showing the marked uniformity of the gas as collected on 2 days about 7 weeks apart. The benzene was not determined in this analysis because the method had not been perfected.

ANALYSIS OF A SAMPLE OF MIXED GAS OF PITTSBURGH MADE  
ON JULY 10, 1914.

Constituent	Formula	Per cent.
Carbon dioxide	CO <sub>2</sub>	2.40
Oxygen	O <sub>2</sub>	0.61
Carbon monoxide	CO	13.63
Hydrogen	H <sub>2</sub>	37.13
Methane	CH <sub>4</sub>	30.92
Ethane	C <sub>2</sub> H <sub>6</sub>	1.92
Propane	C <sub>3</sub> H <sub>8</sub>	0.32
Ethylene	C <sub>2</sub> H <sub>4</sub>	6.36
Propylene	C <sub>3</sub> H <sub>6</sub>	0.70
Butylene	C <sub>4</sub> H <sub>8</sub>	0.12

HEATING VALUE OF THE ILLUMINANTS IN THE MIXED GAS  
OF PITTSBURGH.

In calculating the heating value of mixed gas from the analysis as ordinarily made, a value is usually assigned to the illum-

inants that is an approximation, because the constituents that make up the illuminants have not been exactly known. With this data at hand for the gas of Pittsburgh, the authors show below a value calculated from the complete analysis.

TABLE SHOWING THE HEATING VALUE OF THE ILLUMINANTS IN MIXED ARTIFICIAL GAS.

Constituents	B. t. u. per cubic foot at 0° C. and 760 mm. pressure <sup>1</sup>	Constituents present in the mixed artificial gas	Heating value of the constituents present in the mixed artificial gas
Ethylene.....	1,673	0.0605	110.21
Propylene.....	2,509	0.0060	15.05
Butylene.....	3,265	0.0011	3.59
Benzene.....	4,012	0.0133	53.36
Propane.....	2,654	0.0035	9.29
		<hr/> 0.0844	<hr/> 182.50

According to the above calculations, the illuminants in the gas have a heating value at 0° C. and 760. mm.

pressure of  $\frac{182.50 \times 100}{8.44} = 2,162$  B. t. u. The authors have

included propane in the illuminants as ordinarily determined by absorption in fuming sulphuric acid because propane dissolves to a certain extent in the acid; just how much is not known. It was found that the methane and ethane<sup>8</sup> were soluble to a slight extent. Unquestionably, propane is much more so, because the higher paraffins are more soluble than the lower ones. Excluding propane, the heating value of the illuminants becomes:

$$\frac{173.2 \times 100}{8.09} = 2,141 \text{ B. t. u. per cubic foot at } 0^\circ \text{ C. and}$$

760 mm. pressure.

<sup>1</sup> These heating values were calculated from the values as found by Thomsen. His values are given in Landolt and Börnstein's *Physikalisch-Chemische Tabellen*, 1905, page 425. They are given in large calories per gram molecule.

<sup>8</sup> See Burrell G. A. and Seibert F. M. The sampling and examination of mine and natural gases. Bulletin No. 42, U. S. Bureau of Mines page 47.

### ADDITIONAL DETAILS OF THE EXPERIMENT.

Temperatures higher than the temperature of liquid air are obtained by cooling a natural gas condensate. This condensate was obtained from a natural gas gasoline plant by projecting natural gas (casing head gas) from an oil well to a pressure of 250 pounds per square inch and then cooling it to ordinary temperatures. A steel cylinder such as is used in transporting oxygen, was shipped to the natural gas gasoline plant of the Bessemer Gas Engine Company, at Follansbee, West Virginia, for the purpose of collecting the condensate. This condensate is known in the natural gas gasoline trade as old gasoline. It contains large quantities of liquid propane and the butanes, especially the latter, as well as some of the ordinary gasoline constituents, the pentanes, hexanes, etc. Ordinary refinery gasoline, and other substances such as alcohol, ether, methyl and ethyl chloride, jellied so much at low temperatures that they could not be used satisfactorily. In order to obtain a temperature higher than the temperature of liquid air, say  $-145^{\circ}$  C., the condensate was placed in a Dewar flask and stirred with a test tube into which liquid air was run until  $-145^{\circ}$  C. was reached. Upon removal of the test tube containing the liquid air, the condensate warmed up slowly, about  $5^{\circ}$  to  $10^{\circ}$  C. per hour, thereby affording sufficient time for the withdrawal of the vapors. If the condensate rose to a higher temperature than was desired, it was a simple matter to introduce a little more liquid air and cool

Temperature measurements were made with two pentane thermometers. They agree with each other and gave within  $5^{\circ}$  C. the true melting points of chloroform and carbon disulphide, and the boiling point of liquid carbon dioxide. Fresh liquid air as it reached the laboratory from a plant nearby usually had a temperature of  $-193^{\circ}$  C.

The determination of hydrogen sulphide, acetylene, carbon disulphide, ammonia, etc., that might have been present in the gas, was not attempted, because the method used is scarcely

adapted to the estimation of the traces of these constituents that are present in coal gas.

Future work on the fractionation of artificial gas will cover the analysis of gas that is used in other cities than Pittsburgh, and the separation of the illuminants in the coal gas before it is mixed with carbureted water gas and in oil gas that is used to enrich water gas.

THE CHAIRMAN: Gentlemen, we have here a very interesting presentation of one of the methods of laboratory work. I will ask Mr. Earnshaw to start the discussion on this paper.

MR. E. H. EARNSHAW (Newark): This paper has been of special interest to me because quite a number of years ago it was a part of my duty to find out what was in gas, and the method at my disposal did not admit of the method which Mr. Burrell has just shown us.

The determination of benzene has always been an important point in gas analysis, and it has been difficult to get a correct determination, and it seems to me that the method prescribed here is sufficiently simple to make it possible to use that quite frequently, at least in the ordinary technical examination of the gas; and its control in the processes of manufacture.

It would be of much interest if Mr. Burrell could tell us how his determination of the heat illuminants compared with the calorimetric value of the gas itself. If you know how many heat units there were in a gas, it would be easy to check up and see whether the totals, as determined by this method of analysis, would agree with the totals shown by the instrument. That is not mentioned in the paper, and it would be of interest to know whether that did actually occur.

MR. W. H. FULWEILER (Philadelphia): I wonder whether the question of time has been taken up? I would like to know how long it took to make a determination by this method, especially the determination of benzene.

MR. W. E. HARTMAN (Chicago): I was not present during the reading of the paper, and this question may have

been answered. Does this method of analysis give any better means of determining the practical yield of benzol and its homologues from a coke oven gas?

THE CHAIRMAN: Is there anyone else with anything to bring forward? If not, I will ask Mr. Burrell to answer the questions which have been asked, in closing.

MR. BURRELL: In reply to Mr. Earnshaw's question I would say that the samples of gas were obtained in the laboratory. I see nothing in the way of accurate heating value results being obtained now from the analyses. The value 2,162 B. t. u. was calculated at  $0^{\circ}$  C. and 760 mm. pressure. At a higher temperature, say  $60^{\circ}$  F., it should approach pretty close to 2,000 a value which a number of gas companies use.

In regard to the time, going at it rather blindly, and working up the details, it took us about six weeks. We did not work steadily all the time, probably about four weeks of that time. The last one we analyzed, we finished in two days, and I think in the future, it will be done even quicker than that. It is not a routine method. It is essentially a research method.

Now, as to the time in making the benzene determination, that is quick,—one uses stock articles—the mercury pump, the gas burette and the liquefaction are simple apparatus and methods. Carbon dioxide is obtained in tanks in any large quantity, and a Dewar flask is used for holding it. The operation consists in first taking all the air out of the apparatus. That will take from ten to fifteen minutes; then the coal gas is introduced.

We have not determined the minimum time one has to wait, before the vapors were deposited, but we found ten minutes was perfectly satisfactory. Then, the apparatus is exhausted again, the refrigerant taken away, and the benzene allowed to vaporize. I would say about forty minutes was required to complete the whole operation.

We found coal gas at Pittsburgh to be practically uniform in two samples taken six weeks apart. So if one determines



the composition of the illuminants once, probably they will not change for a long time. So with the heating value, as determined by one analysis, it can be used perhaps for a long time.

THE CHAIRMAN: The next paper is "The Mode of Decomposition of Coal by Heat," by Messrs. H. C. Porter and G. B. Taylor, both of Pittsburgh. Dr. Porter will present the paper.

## THE MODE OF DECOMPOSITION OF COAL BY HEAT.

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### OUTLINE.

Introduction.

Importance of carbonization in general.

Fundamentals of the process; primary and secondary decomposition.

Practical application of these principles in gas manufacture.

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### INTRODUCTION.

Gas, made by the carbonization of coal, is the result of a

number of complex chemical processes, occurring either simultaneously or in rapid succession when coal is heated.

Destructive distillation of carbonaceous matter, or carbonization, involves, first, the primary liberation of volatile decomposition products at low temperatures; second, alteration of the substance by heating at low temperatures; third, liberation of volatile products from this residual altered substance by higher heating; and finally, most important of all, secondary thermal decomposition of the primary volatile products. It is possible in a study of carbonization to separate more or less these various steps.

The present paper is not an attempt to boost low temperature carbonization or vacuum carbonization as an industrial possibility. By all means, let it be understood in the beginning that we are not studying the retort coal-gas process as a whole, nor devising new machines for gas manufacture. Neither has the investigation reached the stage as yet where practical yields and marketable end-products are directly considered.

We have analyzed the process of carbonization, divided it theoretically into steps and, by laboratory means, studied the early steps. A laboratory expedient, *viz.*, the use of a high vacuum with low temperatures of decomposition, has served to minimize the complicating secondary stages of the process and permit an approximate determination of what happens primarily in coal carbonization.

It is hoped that similar studies will be made of the secondary stages, and that by correlation of the two, supplemented by works-scale experiments, practical gas manufacture and fuel utilization in general may be benefitted.

The work of other investigators in this field, as bearing on the primary stages of carbonization, will be reviewed and their conclusions discussed. The experimental methods and some of the results of the present investigation will then be shown by means of a few lantern slides, and an attempt will be made to interpret the results as indicating the nature of the first steps in carbonization and the nature of coal substance itself.

If the use of metric units, such as, *e. g.*, cubic centimeters of gas per gram, is confusing to any of the audience, it is to be remembered that the data are merely comparative among themselves. Comparison of the absolute yields with those of industrial practice is not intended and will not be useful.

#### IMPORTANCE OF CARBONIZATION IN GENERAL.

The subject of carbonization is of importance not only in the processes of gas and coke-making, where it is paramount, but in all other processes as well, for the utilization of coal, wherein the coal itself becomes heated. The formation of gases and volatile liquids by decomposition of the coal substance invariably results by application of heat in even moderate degree, and the behavior and disposal of these volatile products becomes a factor in the efficiency of any such processes. Boiler furnaces, gas-producers, metallurgical furnaces, all involve carbonization if raw coal is the fuel.

Of late years the introduction of novel methods of carbonizing coal, notably the vertical retort, the making of gas in by-product coke ovens, and various low-temperature carbonization processes, has given an impetus to the study of the fundamental processes involved in carbonization.

#### FUNDAMENTALS OF THE PROCESS; PRIMARY AND SECONDARY DECOMPOSITION.

Very little of the final gas resulting from carbonization in bulk at a high temperature can be considered as being present in the primary products liberated from coal. The action of heated surfaces in further decomposing the primary volatile products is a large factor in determining the final products of carbonization. The ease with which these secondary decomposition processes take place causes them to enter largely into most of the industrial carbonization processes.

#### PRACTICAL APPLICATION OF THESE PRINCIPLES IN GAS MANUFACTURE.

The vertical gas retort, by virtue of having a smaller amount

heated open space than the horizontal, in relation to the quantity of coal in the charge, gives a shorter period of contact of a unit of gas quantity with the heated space, hence less secondary decomposition of the volatile in this open space. The verticals do not reduce greatly the total amount of secondary decomposition, but they effect this decomposition more largely in the space occupied by the charge of coal and therefore at lower temperatures than in the free space of the horizontals. For this reason more of the carbon of the coal goes into the tars and less into naphthalene and free carbon.

In certain low-temperature carbonization processes, such as the Del Monte, the primary decomposition products are swept quickly out of the heated zone by a current of auxiliary gas and are cooled by contact with the unheated portions of the coal charge, thus permitting the condensation and recovery of large yields of light oils resembling petroleum.

A wide range of temperature prevails in carbonization, however small the mass of material. Gases and vapors are liberated at a great many different temperatures and pass out of the vessel by the route offering least resistance. Gases issue in both directions from the slowly contracting plastic layer of fused coal. Those formed below about 750° F. (approximately the fusion point) pass out chiefly through the uncoked coal, while those formed above 750° F. (much the larger amount) pass chiefly outside of the plastic layer, through the carbonizing mass and along the walls.<sup>1</sup> The latter portion, however, is by no means all subjected to the temperature of the wall; the issuing gases and vapors are superheated in this manner, but not to the full temperature of the retort itself. Primary decomposition products are formed throughout the carbonizing mass, partly at low temperatures from the original coal substance, and partly at higher temperatures from the altered substance. The amount and character of the secondary decomposition, the

<sup>1</sup> For a careful experimental investigation of the question of direction of gas travel in the charge of a vertical gas retort, see O. B. Evans, *Ind. Eng. Chem. Anal. Ed.*, **9**, 338, (Dec. 1, 1913).

thermal reactions or "cracking" processes, undergone by the primary volatile matter, are largely responsible in gas making for the yield and quality of the final product.

#### SCOPE AND OBJECT OF INVESTIGATION.

The present investigation is essentially, then, a study of the decomposition of coal in its early stages, eliminating as much as possible the secondary reactions which complicate the process in industrial practice. Before a satisfactory study can be made of the secondary thermal reactions we must know what the primary reacting bodies are and the proportions in which they are present. Further experimentation upon the gases and liquids primarily produced,—hydrocarbons,  $\text{CO}_2$ , light oils, and water,—will aim to establish for the secondary superheating stage of the process, those conditions of temperature, pressure and time of contact which will give highest yields and highest quality in gas and by-products.

#### THE USE OF VACUUM IN THE STUDY OF CARBONIZATION.

In order to reduce secondary reactions to a minimum we must, first of all, eliminate as far as possible the heated open space over the coal. Two further expedients are then available. We may sweep out the primary products rapidly from the heated section by a current of auxiliary gas; or we may heat the coal under an atmosphere of greatly reduced pressure and draw the volatile products thus very quickly out of the heated section. The former method has the disadvantage of contaminating the gases from the coal with the auxiliary gas used and thus rendering precise analysis difficult. For that reason, in the experiments described below, the vacuum method was adopted.

Whether it is justifiable to assume that under vacuum we obtain the same primary decomposition products as are formed at normal pressure, in a gas retort, for example, may be open to question.

We have considered carefully whether the mode of primary decomposition is affected by reducing the pressure and whether decomposition under such conditions begins at a lower temperature. Experiments were made to throw light on this point. Samples of dry coal were heated at  $482^{\circ}$  F. in a full atmosphere of nitrogen. Approximately the same amounts of gas and of water of decomposition were produced as in a parallel run in vacuo. (See pp. 280-281.)

The indications are that the decomposition of the coal substance is not materially changed in character nor its temperature of beginning greatly lowered by reduction of pressure. Notwithstanding this indication it is reasonable to suppose that when the primary volatile products are removed more quickly from contact with the decomposing solid, the reactions would, by the principle of mass action, proceed more rapidly, and that the rate of decomposition of coal should accordingly be somewhat more rapid in vacuo than under normal pressure. But the nature of the first products of the decomposition and the relative proportions in which they are formed depend not so much on the total pressure as upon the relative partial pressures in the atmosphere surrounding the coal. We are therefore justified in using the experimental results of the heating of coal in vacuo to throw light on the nature of the primary products of decomposition in industrial processes wherein coal is distilled under normal pressure.

The important effect of vacuum in these experiments or in any carbonizing experiments is the removal of the tar vapors more quickly from the heated zone, so that they are recovered with less alteration by thermal decomposition. In carbonization at normal pressure these same primary tars are formed but they remain longer in the heated zone and are partially decomposed.

Tables I-VIII: Water, tar and various gases produced by heating 10 grams of different coals for 10 minutes (see *Bulletin 1*, Bureau of Mines, pages 36-39).

TABLE I.—WATER (PERCENTAGE OF AIR-DRIED COAL.)\*

Coal	Average temperature of coal, °C.**				
	375°	475°	600°	700°	850°
Pittsburgh, Pa. ....	—	2.9	2.9	4.0	4.7
Pocahontas, W. Va. . .	0.8	1.2	1.7	2.1	2.7
Ziegler, Ill. ....	—	12.2	13.6	13.5	14.4
Dietz, Wyo. ....	14.5	21.0	18.1	18.7	24.3

\* Includes free moisture present in the coal used. Pittsburgh, 1.10 per cent.; Pocahontas, 0.47; Illinois, 7.54; Wyoming, 11.14.

\*\* Temperature in coal was 50°–125° C. below that of furnace.

TABLE II.—TAR (PERCENTAGE OF AIR-DRIED COAL).

Coal	Average temperature of coal, °C.				
	375°	475°	600°	700°	850°
Pittsburgh, Pa. ....	—	5.2	11.6	13.2	12.5
Pocahontas, W. Va. . .	0.3	1.0	4.4	6.7	6.7
Ziegler, Ill. ....	—	6.7	8.2	9.7	9.1
Dietz, Wyo. ....	2.0	2.4	8.6	8.3	9.9

TABLE III.—CO<sub>2</sub> (IN CC. PER GRAM OF AIR-DRIED COAL).

Coal	Average temperature of coal, °C.				
	375°	475°	600°	700°	850°
Pittsburgh, Pa. ....	—	1.4	2.3	2.3	5.2
Pocahontas, W. Va. . .	—	0.9	1.3	2.2	4.2
Ziegler, Ill. ....	4.7	3.4	6.0	5.4	8.3
Dietz, Wyo. ....	6.4	18.4	31.5	38.3	42.3

TABLE IV.—CO (IN CC. PER GRAM OF AIR-DRIED COAL).

Coal	Average temperature of coal, °C.				
	375°	475°	600°	700°	850°
Pittsburgh, Pa. ....	—	1.4	5.5	11.3	15.5
Pocahontas, W. Va. . .	—	0.6	2.6	8.6	11.5
Ziegler, Ill. ....	1.7	3.1	10.5	21.3	32.7
Dietz, Wyo. ....	1.2	6.4	21.8	41.5	51.4

TABLE V.—METHANE (IN CC. PER GRAM OF AIR-DRIED COAL).

Coal	Average temperature of coal, °C.				
	375°	475°	600°	700°	850°
Pittsburgh, Pa. ....	—	8.0	29.0	40.5	62.4
Pocahontas, W. Va. . .	—	2.1	30.3	43.8	77.3
Ziegler, Ill. ....	2.6	4.0	22.8	38.3	61.3
Dietz, Wyo. ....	0.1	1.9	20.4	27.2	39.2

TABLE VI.—HIGHER HYDROCARBONS OF THE METHANE SERIES  
(CALCULATED AS  $C_7H_8$ ), (CC. PER GRAM OF AIR-DRIED COAL).

Average temperature of coal, °C.

Coal	375°	475°	600°	700°	850°
Pittsburgh, Pa. ....	—	5.8	19.4	20.0	14.6
Pocahontas, W. Va. .	—	1.9	11.2	20.6	5.9
Ziegler, Ill. ....	—	4.8	6.8	8.4	6.1
Dietz, Wyo. ....	0.1	1.5	7.6	7.7	8.0

TABLE VII.—UNSATURATED HYDROCARBONS (CC. PER GRAM  
OF AIR-DRIED COAL).

Average temperature of coal, °C.

Coal	375°	475°	600°	700°	850°
Pittsburgh, Pa. ....	—	1.9	5.7	8.9	11.5
Pocahontas, W. Va. .	—	0.6	3.0	6.2	7.7
Ziegler, Ill. ....	—	1.5	2.2	5.1	7.4
Dietz, Wyo. ....	0.1	1.1	4.1	5.2	6.6

TABLE VIII.—HYDROGEN (CC. PER GRAM OF AIR-DRIED COAL).

Average temperature of coal, °C.

Coal	375°	475°	600°	700°	850°
Pittsburgh, Pa. ....	—	0.5	21.0	54.4	108.8
Pocahontas, W. Va. .	—	0.2	19.1	77.6	127.1
Ziegler, Ill. ....	—	0.6	15.7	46.7	108.2
Dietz, Wyo. ....	—	—	16.6	58.2	97.1

TABLE IX.—QUANTITIES (CC. PER GRAM) OF DIFFERENT GASES OBTAINED FROM PITTSBURGH COAL BY HEATING 10 GRAMS FOR 10 MINUTES.

Average temperature of coal, °C.

Gas	475°	600°	700°	850°
CO <sub>2</sub> .....	1.4	2.3	2.3	5.2
CO .....	1.4	5.5	11.3	15.5
CH <sub>4</sub> .....	8.0	29.0	40.5	62.4
C <sub>2</sub> H <sub>6</sub> , etc .....	5.8	19.4	20.0	14.6
Unsaturated hydrocarbons...	1.9	5.7	8.9	11.5
Hydrogen .....	0.5	21.0	54.4	108.8
Totals .....	19.0	82.9	137.4	218.0

TABLE X.—PERCENTAGES OF VOLATILE MATTER (WITHOUT MOISTURE) AND OF COMBUSTIBLE VOLATILE MATTER, FROM PITTSBURGH AND WYOMING COALS (HEATING 10 GRAMS FOR 10 MINUTES).

Average temperature of coal, °C.

Coal	475°	600°	700°	850°
Pittsburgh:				
Total volatile .....	8.9	19.7	24.3	26.8
Combustible volatile .....	6.8	17.5	21.0	22.3
Wyoming:				
Total volatile .....	16.6	26.4	31.0	41.3
Combustible volatile .....	3.5	13.9	16.7	20.7



THE NATURE OF THE PRIMARY DECOMPOSITION PROCESS;  
SUMMARY OF PREVIOUS INVESTIGATIONS.

In Table I-X and Figs. 1-4 are shown the results of some previous investigations by the Bureau of Mines on "The Volatile Matter of Coal," published as *Bulletin 1*, 1910. This work brings out chiefly the wide difference between coals in the character of their volatile matter and indi-

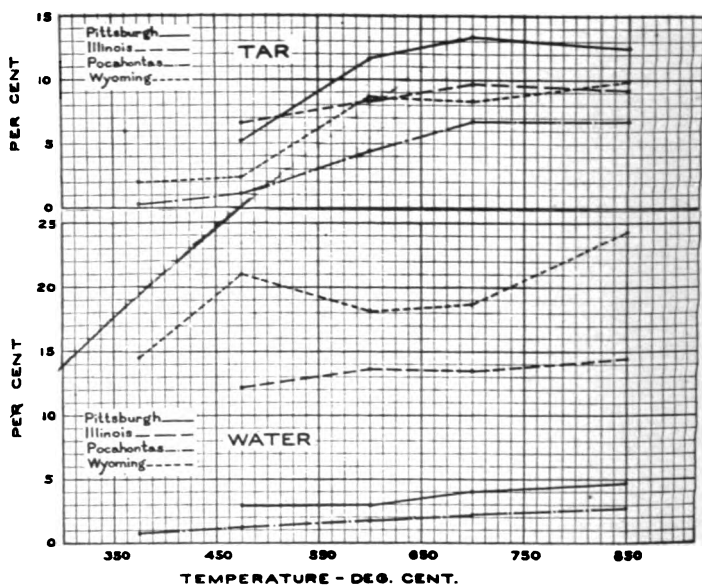


Fig. 1.—Tar and water produced by heating different coals at different temperatures (*Bulletin 1*, Bureau of Mines).

cates that the primary decomposition products are  $\text{CO}_2$ , water, and hydrocarbons, the last-named (including the tar) being the chief product from the older bituminous and gas coals. These tests were made in a platinum retort on 10 grams of coal in an atmosphere of nitrogen. Only the products formed in the early period of heating were collected. The predominance of tar in the early low-temperature products from Pittsburgh coal is to be noted, and of the various hydrocarbons of the methane type in the low-temperature gases. On the other

hand, the predominance of non-combustible inert constituents in the early volatile matter from the western coals,—not of the gas-making type,—is very evident from Fig. 4.

Since these experiments were made several other investigators have examined the tars and oils produced in low-temperature carbonization.

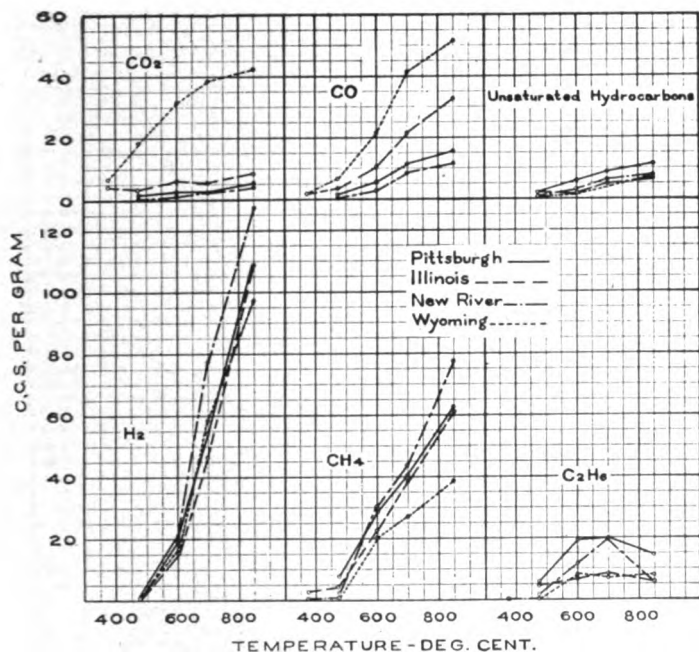


Fig. 2.—Quantities of various gases produced by heating different coals at different temperatures (Bulletin 1, Bureau of Mines).

Parr and Olin, at the University of Illinois<sup>2</sup> treated Illinois coal at 842° F. with superheated steam. They obtained a yield of tar nearly equal to that produced by high-temperature distillation, while the gas yield by volume was less than 10 per cent. of that at high-temperature. About 70 per cent. of the tar was comprised in fractions distilling below 240° C. and only a small amount of free carbon was present.

<sup>2</sup> Bull. 60, Univ. of Ill. Engrg. Expt. Sta., 1912.

Pictet and Bouvier<sup>3</sup> obtained at 842° F. in a partial vacuum a thin tar containing apparently no phenols, naphthalene, anthracene or other aromatic compounds.

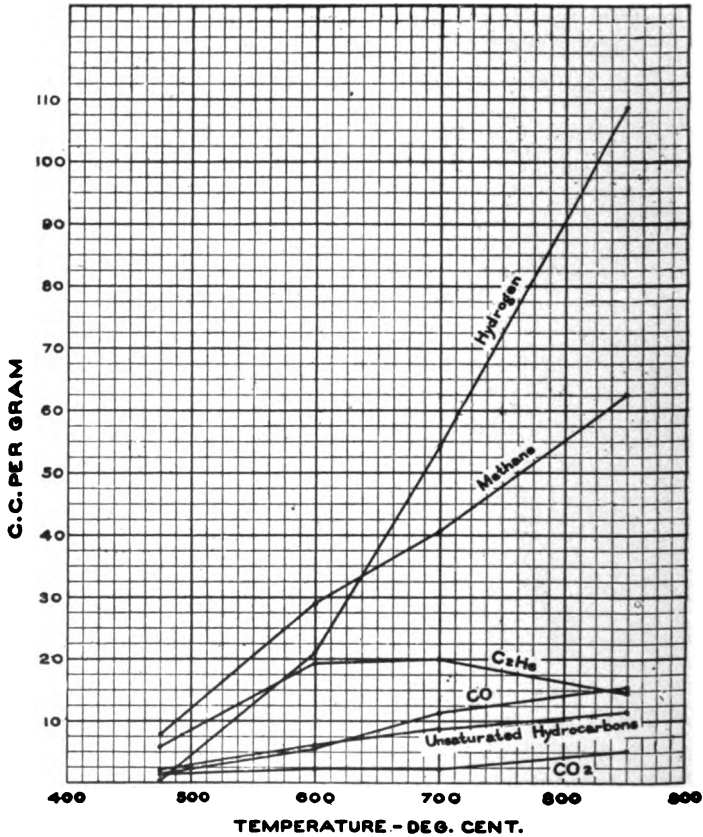


Fig. 3.—Gases from Pittsburgh coal at different temperatures (Bulletin 1, Bureau of Mines).

R. V. Wheeler and associates in England have carried on investigations of the destructive distillation of coal chiefly with

<sup>3</sup> Compt. rend., 137, 1913, 779.

view to its bearing upon the process of ignition or inflammation of coal dust suspended in air.<sup>4</sup>

In some of their more recent work<sup>5</sup> especial study was made of the tar produced by vacuum distillation at 430° C. (806° F.). Half of this tar consisted of oils boiling below 300° C. (572° F.), the remainder being a pitch entirely soluble in

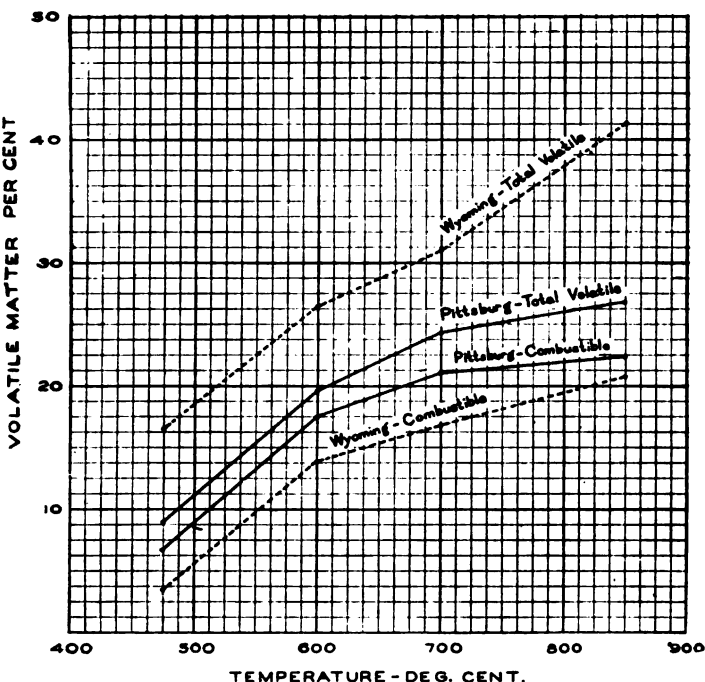


Fig. 4.—Percentages of volatile matter, comparing total and combustible, at different temperatures, Pittsburgh and Wyoming coals (Bulletin 1, Bureau of Mines).

chloroform and containing no free carbon. The oils contained no benzene, or any of its homologues, and no anthracene or other solid aromatic hydrocarbons. Phenols, however,

<sup>4</sup> Jour. Chem. Soc. (T), 97, 1910, 1921; 99, 1911, 649; 103, 1913, 1704, 1715; 105, 1914, 131, 140.

<sup>5</sup> Jones and Wheeler, Jour. Chem. Soc., 105, 1914, 140.

(in disagreement with the results of Pictet and Bouvier), were present to the extent of 12-15 per cent. of the oil, and homologues of naphthalene constituted about 7 per cent. The major portion of the oil (about 80 per cent.) consisted of a mixture of ethylenic hydrocarbons and the ring-formed naphthenes ( $C_nH_{2n}$ ) intermediate in character between the paraffin and aromatic compounds.

Whether any of the compounds found in the liquid distillates from coal at low temperatures exist as such in the coal is still a matter of conjecture, but it is rendered extremely doubtful by the fact that extraction of coal with solvents has not effected the separation of any of these substances in more than mere traces. The predominance of paraffin compounds in both the liquid and gaseous products of moderate heating is beyond question, the aromatic compounds or those whose formulas are built upon the benzene ring as a nucleus are present either not at all or in very small percentages. If we disregard the aqueous distillates, the early products of the decomposition of coal are made up chiefly of paraffin hydrocarbons.

It is of interest to consider in some detail, what has been learned as to the production of water and other oxygen compounds during the early stages of the decomposition of coal by heat. Wheeler finds<sup>6</sup> by gradually raising the temperature of dry coal in vacuo that "at 200° C. there is a copious evolution of water;" also that "the gases evolved during the period of most rapid formation of water contain a high percentage of the oxides of carbon."

Rau and Lambris<sup>7</sup> have recently conducted a thorough investigation of the formation of water in the destructive distillation of fuels. They found that the mode of decomposition is dependent upon the rapidity of heating, and that the water of decomposition is greater by 50-100 per cent. with slow heating than with rapid heating. With a high-grade gas coal, the water of decomposition varied from 4.8 per cent. to

<sup>6</sup> Jour. Chem. Soc., 105, 132.

<sup>7</sup> Jour. für Gasbeleuchtung, 56, 1913, 533, 557, 589.

3 per cent. according to whether the coal was heated to 1,000° C. in a few minutes or in 36 hours. Fuels of greater maturity (less oxygen content) produce less water and produce it at a higher temperature than the younger less altered fuels. With cellulose the principal water formation occurs between 240° and 350° C. (464° and 662° F.), with bituminous coal between 400° and 650° C. (752°-1,202° F.).

The experimental results given in *Bulletin 1* of the Bureau of Mines (see pages 5-6 and Table I page 7) show the large variation among American coals in the amount of water yielded by decomposition, and in general they conform to the results of Rau and Lambris quoted above. The results of vacuum distillation obtained in recent work of the Bureau and presented later in this paper (page 263) have shown a yield of water of decomposition at 450° C. (842° F.) of 4.3 per cent. from Pittsburgh gas coal, 8.3 per cent. from an Illinois bituminous, and 12.6 per cent. from a Wyoming sub-bituminous type. These yields of water constituted respectively 20 per cent., 38.8 per cent., and 42.9 per cent. of the total volatile matter at that temperature.

It is evident that water constitutes a large percentage of the primary decomposition products of coal and that its formation takes place principally below 500° C. (932° F.). From the more mature coals such as the Pittsburgh, water and the oxides of carbon are formed in less amount than are tar and hydrocarbons, while in case of the Wyoming coal the reverse is true. We are led to conclude therefrom that the water-yielding constituents of coal are principally the less-altered cellulosic derivatives occurring more abundantly in the younger coals, and that these substances decompose easily by heat; that, in fact, since water and CO<sub>2</sub> appear as large percentages of the first decomposition products collected, the cellulosic derivatives are among the most easily decomposed of all the constituents of coal.

Researches upon the production of gas in the decomposition of coal have been more numerous than those upon the tars

and the water of decomposition. Among these we may note in some detail, as bearing particularly upon the primary decomposition processes, the work of Wheeler, above referred to.

He found that when coal was heated at temperatures below  $700^{\circ}\text{C}$ . ( $1,292^{\circ}\text{F}$ .) the gas formed was made up of 50-75 per cent. of paraffin hydrocarbons; above  $750^{\circ}$  ( $1,382^{\circ}\text{F}$ .) the quantity of these hydrocarbons produced was very small and the quantity of hydrogen very large. "Presumably, then," he concludes, "coal contains two types of compounds, of different degrees of ease of decomposition; the one the more unstable yielding the paraffin hydrocarbons and no hydrogen; the other decomposed with greater difficulty yielding hydrogen alone (or possibly hydrogen and the oxides of carbon) as its gaseous decomposition product."<sup>8</sup> In another place,<sup>9</sup> he says: "The results . . . show clearly the existence of . . . 'hydrogen-yielding' and 'paraffin-yielding' substances as separate constituents of coal; . . . the former are the degradation products of the celluloses and the latter the resinous substances originally present in the coal plants."

These conclusions as to the mode of decomposition of coal substance seem to us to be not entirely justified by the experimental results. Much more plausible, we believe, is the tentative conclusion drawn by the same authors in an earlier paper<sup>10</sup> that "it seems probable that this same compound" (*i. e.*, the one yielding principally hydrogen above  $700^{\circ}\text{C}$ .) "is responsible for the hydrocarbons of the paraffin series that make their appearance at low temperatures." In other words, coal does not seem to contain a substance which remains unaltered or nearly so below  $750^{\circ}\text{C}$ . ( $1,382^{\circ}\text{F}$ .) and rapidly produces hydrogen above that temperature. It seems rather to contain a substance,—in fact, gas coal is probably largely made up of substances which yield the complex paraffin hydrocarbons at low temperatures and a large amount of hydrogen at high

<sup>8</sup> Jour. Chem. Soc., 99, 1911, p. 651.

<sup>9</sup> Jour. Chem. Soc., 103, 1913, p. 1705.

<sup>10</sup> Jour. Chem. Soc., 97, 1910, p. 1918-1919.

temperatures from the decomposition residue. There is no well-marked "critical point" in the decomposition of coal. There is, however, a well-marked critical point between 1,300° and 1,450° F. in the secondary decomposition of the volatile matter,—tar and gases.

In support of this view we may cite Wheeler's own results. The curve for total volatile rises with remarkable regularity from 600° to 900° C. (1,100° to 1,650° F.). There is no sudden rise between 700° and 800° C. On the other hand, tar reaches its maximum at 750° C. (1,380° F.) and then declines rapidly. The sudden rapid production of hydrogen at 750° C. may well be caused, therefore, by decomposition of tar, which adds a large volume of hydrogen to that produced from the altered solid residue.

The volatile obtained at 700° C. (1,290° F.) was 32.3 per cent. as compared to a maximum of 38.8 per cent. at 1,100° C. (2,010° F.), a fact indicating that there is relatively only a small portion of coal, if any, which remains undecomposed at 700° C. (1,290° F.). It is unlikely from the point of view of the origin of coal, that so large a proportion of coal substance as that decomposing below 700° C., is made up essentially of resinous derivatives.

Furthermore, Wheeler's researches<sup>11</sup> on the treatment of coal with pyridene, extracting thus certain soluble portions and subjecting the residues to destructive distillation, show that there was not in this manner brought about a segregation or concentration in the residue of a constituent which would yield hydrogen rapidly at 750° C. We may show here his results of these experiments (see Table XI and Fig. 5).

TABLE XI.—HYDROGEN BY DESTRUCTIVE DISTILLATION.

	(WHEELER.) (Cc. per gram.)				
	600°	700°	800°	900°	1,000°
Original coal.....	26.4	40.6*	105.9	149.3	172.0
Pyridine residue .....	20.7	49.1	82.9	141.5	187.2
Chloroform-pyridine extract ..	14.6	26.9	53.2	70.2	87.5

\* In another report of these same experiments (Record of the 1st Series, British Coal Dust Experiments, Mining Association of Great Britain, 1910, Table II, p. 124), this value appears to be 53.5 cc.

<sup>11</sup> Jour. Chem. Soc., 103, 1913, p. 1704.



There appears to be no more marked rise in the production of hydrogen at 700°-800° C. from the extraction residue than from the original coal.

The experiments just cited show incidentally (by analyses not here quoted) that the residue from pyridine extraction

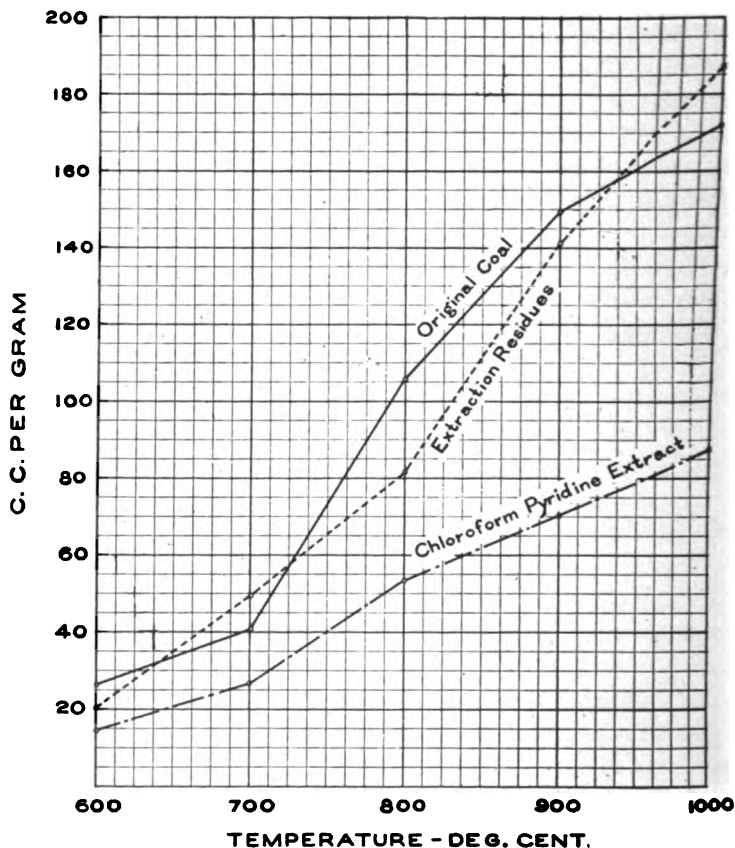


Fig. 5.—Hydrogen obtained at different temperatures from coal and from the fractions separated by pyridine extraction (Wheeler).

yields on destructive distillation more  $\text{CO}_2$  and  $\text{CO}$  than the original coal and that it decomposes as easily at low temperatures as the original coal.

Wheeler's apparatus for heating coal at different temperatures furthered the secondary decomposition of tars and gases. The coal was held in a platinum boat resting in a heated cylindrical platinum retort. The products passed through a heated scrubber in the end of the retort itself, decomposition undoubtedly occurring here as well as on the retort walls above the boat. The tests were run at normal pressure.

The production of hydrogen in coal distillation in relatively large quantities above  $750^{\circ}\text{C}$ . ( $1,382^{\circ}\text{F}$ .) is to be ascribed partly to the secondary decomposition of tar vapors (heavy hydrocarbons) and partly to the decomposition of solid residues from the earlier breaking down of the original substance. That a "hydrogen-yielding" substance, decomposable only above  $750^{\circ}\text{C}$ ., exists in the original coal, seems to be an reasonable conclusion from the facts at hand.

The fundamental problems of coal distillation cannot be solved by a method which leaves out of consideration the secondary decomposition of the early volatile products. Many investigations have been made in recent years in which coal was heated at normal pressure in an iron tube or other form of retort, necessitating the passage of the products through a relatively large heated section. The gases obtained thus do not represent what is formed by decomposition of coal at any given temperature, but what results from secondary reactions of the volatile products under the particular conditions in the apparatus used. We need not therefore quote further from such investigations since nothing has been added by them to the results of Wheeler described above.

#### EXPERIMENTS ON DECOMPOSITION OF COAL UNDER REDUCED PRESSURE AT MODERATE TEMPERATURES.

Having stated the problem in hand, and called attention to the work of other investigators, we may pass now to an account of our own experiments relating to the primary decomposition processes.

*Apparatus and Methods.*

Four kinds of coal (described in Table XIII, p. 25) were heated at 250°, 350° and 450° C. (482°, 662° and 842° F.) in a glass bulb, completely filled with the coal, and whose walls were at no point heated above the temperature of the coal; maintaining in the bulb and apparatus attached a vacuum vary-

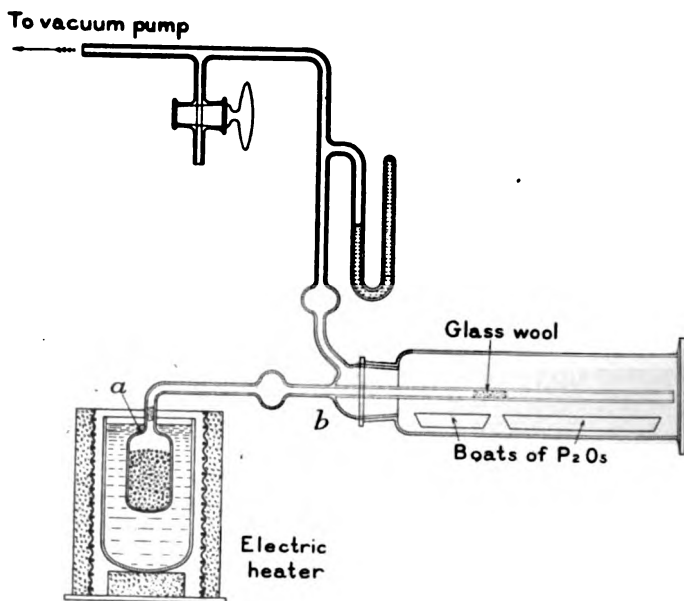


Fig. 6.—Apparatus for the heating of coal at moderate temperatures in vacuo.

ing from 0.5 mm. to 10 mm. of mercury. The coal was in the air-dried condition, sized between 40 and 100-mesh. At the two lower temperatures 15-gram samples were used while at 450° C. (842° F.), on account of the greater amount of gas produced, 5 grams only were taken.

The apparatus used in most of the tests is shown in Fig. 6.

The gases were drawn by the vacuum pump quickly out of the retort, through the pump and into a collecting reservoir. Considerable oily products were largely retained in an air-cooled trap just in advance of the retort, while water (together with ammonia, phenols, and nitrogen bases) was absorbed in a weighed vessel of phosphorus pentoxide between the retort and pump. A small amount of light oils (paraffin hydrocarbons) which under atmospheric pressure would have been retained in the tar, no doubt passed on into the gas under the influence of the reduced pressure in the apparatus. In most of the tests (excepting only the one at  $450^{\circ}$  on Wyoming sub-bituminous coal) practically no oily products condensed with the water in the phosphorus pentoxide. The yields of water and gas were directly determined, as well as the loss in weight of the coal or total volatile matter. Owing to the experimental difficulty of collecting and weighing all of the tar, this product was determined by difference, subtracting from the total volatile matter the sum of the water and the calculated weight of gases.

The heating bath was a mixture of salts (sodium and potassium nitrates) melting at about  $220^{\circ}$  C. ( $428^{\circ}$  F.). Boats containing phosphorus pentoxide were used to collect water, being withdrawn at *b* (Fig. 6) after each run, and weighed. No rubber connections were used in the apparatus.

The procedure in beginning a test was as follows: The trap containing the weighed sample of coal having been joined to the apparatus, and the weighed boats of phosphorus pentoxide having been inserted, the air was exhausted until a vacuum of less than 1 mm. of mercury remained constant. As shown by trial of this constancy of pressure over several hours, there appeared to be little or no evolution of occluded gases in vacuo at ordinary temperature, probably because of the fact that the coals had been several years out of the mine and the rate of liberation of gas had become very slow. The electric heater containing the molten-nitrate bath was then used so as to begin the heating of the coal, the bath being,

however, only about half full at the beginning so that the surface of the molten nitrates just touched the bulb. In this manner the heating was begun gradually, about  $\frac{1}{2}$  hour usually being required to bring the bath to the temperature of the experiment and completely to immerse the bulb. By operating the pump rapidly, when required, the gases were removed at such a rate that the pressure was kept below 10 mm. of mercury, except in case of the sub-bituminous coal with which the pressure rose for a few seconds to 15-20 mm. Also in certain long-continued tests the pressure occasionally rose during the night to 25 mm. of mercury. In these tests, however, a large evacuated chamber 80 to 100 times the capacity of the distilling bulb was interposed between the bulb and the pump (see Fig. 7) and served to reduce greatly the amount of volatile products remaining in the heated bulb during the interval between exhaustions.

#### *Methods of Gas Analysis.*

The methods of gas analysis used were an adaptation of the best features of several well-known methods to the peculiar requirements of the gases of low-temperature distillation.

Certain peculiar difficulties rendered the ordinary methods unavailable. The apparatus used has been described in a recent publication.<sup>12</sup>

The method of analysis is not new, but it involves a method of manipulation not commonly used and which may well be outlined here on account of the importance of correct gas analysis in an investigation of this character. In using the liquid absorbing reagents, the gas was treated with a small quantity of the reagent, fresh each time. All analyses were carried out over mercury. From the measuring burette (see Fig. 8) the sample was passed into one of the pipettes DE (filled with mercury) into which the liquid reagent had been previously introduced from below by means of a bent-tube pipette. By passing the gas back and forth several times from burette to pipette the absorption was facilitated. After the

<sup>12</sup> Journ. Ind. and Eng. Chem., Oct., 1914, p. 845.

orption the reagent was discarded through the cock *k* into waste cup G, to which suction was attached. The reagents used were, in order, the following:

For  $\text{NH}_3$ , dilute  $\text{H}_2\text{SO}_4$  (10 per cent.).

For  $\text{H}_2\text{S}$ , acid  $\text{CuSO}_4$  solution.

For  $\text{CO}_2$ , 33 per cent.  $\text{KOH}$  solution.

For unsaturated hydrocarbons and benzene, fuming  $\text{H}_2\text{SO}_4$ .

For oxygen, alkaline pyrogallol.

The error in determination of unsaturated hydrocarbons due to absorption of higher paraffins by the fuming sulphuric acid in this method much reduced by the use of only a few cubic centimeters of the reagent. Slightly soluble gases are thus sorbed only in slight amounts.

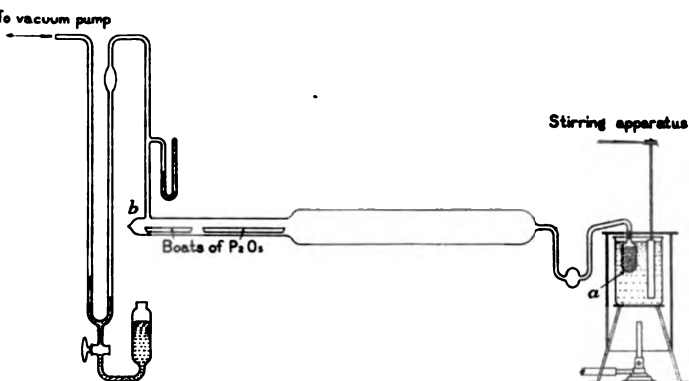


Fig. 7.—Apparatus for long-continued heating of coal in vacuo.

Having absorbed  $\text{NH}_3$ ,  $\text{H}_2\text{S}$ ,  $\text{CO}_2$ , unsaturated hydrocarbons and oxygen by liquid reagents, hydrogen and  $\text{CO}$  were next determined by Jaeger's method of fractional combustion with copper oxide. A U tube of about 5 mm. bore containing copper oxide was attached to the apparatus in inverted position as shown at C. A special electric heater, H, of such shape and size as to fit closely over the U tube, was lowered over the tube and the latter heated to the desired temperature. The air in

the tube having been swept out by the gas sample, the oxygen was absorbed by pyrogallol, and the gas volume then measured with the tube at room temperature. The gas was then passed back and forth through the heated copper oxide, burning thus the CO and H<sub>2</sub>. When no further contraction of volume occurred, the U tube was brought to room temperature, and the contraction and CO<sub>2</sub> measured. The CO<sub>2</sub> found is equal to the CO in the sample and the contraction equals the hydro-

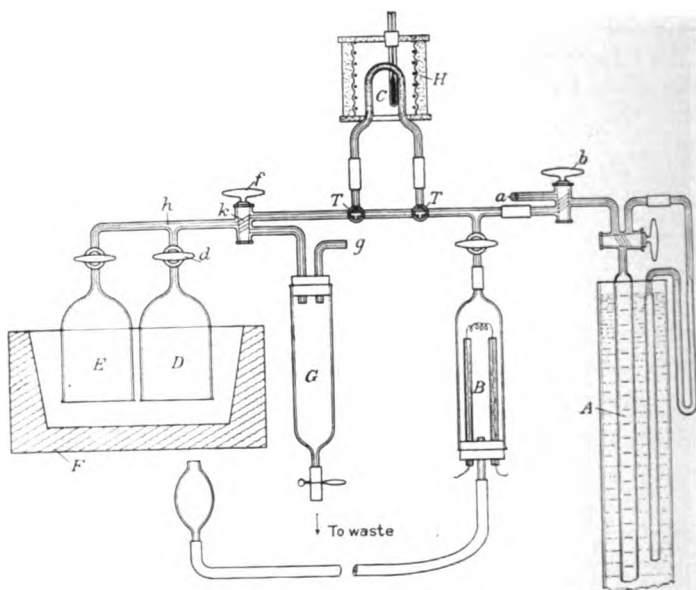
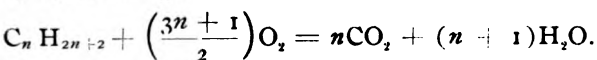


Fig. 8.—Apparatus for analysis of complex gas mixtures.

gen. The accuracy of this method of separating CO and hydrogen from CH<sub>4</sub> and other paraffins depends on the temperature of the copper oxide. If this is properly controlled, hydrogen and CO can be completely burned while CH<sub>4</sub> and its higher homologues (at least those not higher than butane) remain unattacked. In our work the temperature inside the heater, next to the U tube, was kept at 275° C. It was found by tests upon natural gas and pure hydrogen mixtures (no CO present) that at this temperature complete burning of the hy-

took place and the hydrocarbons of natural gas were measurably attacked. Since CO is known to burn, by this, more easily than hydrogen, the assumption was made also had burned completely at this temperature. A experiment should always be run on known mixtures to the effect of the temperature and other conditions *as used*. Saturated paraffin hydrocarbons ( $\text{CH}_4$ ,  $\text{C}_2\text{H}_6$ ,  $\text{C}_3\text{H}_8$ , etc.) when burned completely with oxygen by passing the residue over a glowing platinum coil, in the combustion pipette the oxygen was passed first into the combustion pipette the platinum coil brought to a bright-red heat. The combustible residue was then passed very slowly *into* the oxygen and burned. By having in this manner a large excess of oxygen always present no deposition of carbon occurred from higher hydrocarbons. After cooling to room temperature contraction and  $\text{CO}_2$  were measured, and thence were calculated the total volume of  $\text{C}_n\text{H}_{2n+2}$  hydrocarbons and the value of  $n$  in the formula representing the mixture. This method of calculation was developed by E. H. Earnshaw<sup>18</sup> and follows:

Assuming no combustible gases other than those of the form  $\text{C}_n\text{H}_{2n+2}$  the general equation for the combustion is



If the volume of  $\text{C}_n\text{H}_{2n+2}$  be called  $V$ , the  $\text{CO}_2$  produced  $A$ , the contraction  $C$ , then:

$$A = nV, \quad (1)$$

$$\begin{aligned} C &= \left(V + \frac{3n+1}{2}V\right) - nV, \\ &= V\left(\frac{n+3}{2}\right), \end{aligned} \quad (2)$$

$$\text{From (1),} \quad n = \frac{A}{V},$$

$$\text{Combining (1) and (2), } V = \frac{2C - A}{3}.$$

Proc. Frank. Inst., Sept., 1898.



By this means, regardless of the number of different hydrocarbons of this general formula which are present or of the relative proportions in which they are present, we determine definitely their total volume, and the average number of carbon atoms in the molecule ( $n$ ). We cannot, however, determine thus the volume of any one hydrocarbon, methane for example, in the mixture, since the method of calculation is inadequate for this purpose if more than two hydrocarbons be present. If it be desired to assume only  $\text{CH}_4$  and  $\text{C}_2\text{H}_6$  present we can calculate the quantities of each present, since in this case the value of  $n$  increases in proportion to the percentage of  $\text{C}_2\text{H}_6$  in the mixture. Thus in pure  $\text{CH}_4$ ,  $n = 1$ , in pure  $\text{C}_2\text{H}_6$ ,  $n = 2$ , in a half-and-half mixture  $n = 1.50$ , etc., etc. In interpreting some of the results of low temperature distillation we have used this assumption in order to show the relative proportions of methane and of higher hydrocarbons in the gas. When estimated thus, however,  $\text{CH}_4$  appears in lower than its true proportion, since the higher hydrocarbons when estimated entirely as  $\text{C}_2\text{H}_6$  are greater in amount than when estimated as a mixture of  $\text{C}_2\text{H}_6$ ,  $\text{C}_3\text{H}_8$ ,  $\text{C}_4\text{H}_{10}$ , etc.

*Description of Coals Used.*

Four kinds of coal were used in these experiments on heat-

TABLE XIII.—ANALYSES AND DESCRIPTION OF COALS.

Number (see description below):	674	650	48	43
Air-dried (as used):				
Moisture .....	0.60	0.93	2.07	5.98
Volatile matter .....	21.60	33.02	35.21	41.47
Fixed carbon .....	74.57	56.98	53.55	46.09
Ash .....	3.23	9.07	9.17	6.46
Sulphur .....	0.68	1.81	1.17	1.02
Carbon .....	85.92	76.73	71.80	65.63
Hydrogen .....	4.76	5.00	4.79	5.27
Oxygen .....	3.96	5.86	11.52	20.13
Nitrogen .....	1.45	1.53	1.55	1.49
Calorific value .....	8,412	7,601	6,980	6,410
Calculated to dry, ash-free material:				
Volatile matter .....	22.42	36.69	39.70	47.35
Carbon .....	89.30	85.25	80.91	74.94
Hydrogen .....	4.88	5.45	5.14	5.26
Oxygen .....	3.60	5.59	10.89	16.93

low temperatures. They were representative of dis-  
types or classes of coal, only one, however, (No. 650)  
of the class of coals used for gas-making.

*Description.*

674. Sun mine, Sewell bed, Fayette County, West Vir-  
New River district), mine sample, 4 years since min-

650. Keystone Shaft mine, Madison, Westmoreland  
, Pa. (Pittsburgh bed), car sample, 1 year since min-

48. Dering No. 11 mine, West Frankfort, Franklin  
, Illinois, mine sample, 5 years since mining.

TABLE XIV.—PRODUCTS OF HEATING COAL AT 250° C. (482° F.)

	650 (Pitts- burgh)	674 (New River)	48 (Illin- ois)	43 (Wy- oming)
Sample No.....	60	61	62	65
Weight of coal (air-dry).....	15.0	15.0	15.0	15.0
Time of test (hours).....	7.0	6.5	6.75	7.0
Loss of volatile matter (without moist- ure).....	0.73	0.66	2.61	4.69
Percentage.....	0.13	0.04	0.32	—*
Loss of decomposition (per cent.)..	0.50	0.50	1.95	3.65
Percentage.....	0.10	0.12	0.35	1.04
Weight per 100 grams) (for cubic feet per ton divide by 3.1) .....	57.0	110.0	267.0	659.0
Ammonia and H <sub>2</sub> S .....	—	6.0	21.0	23.0
.....	34.0	42.0	156.0	478.0
.....	6.0	12.0	35.0	81.0
Saturated hydrocarbons, etc....	1.0	1.0	2.0	6.0
Saturated hydrocarbons (C <sub>n</sub> H <sub>2n+2</sub> )	3.0	5.0	6.0	21.0
Hydrogen .....	0.0	—	—	—
Value of n in C <sub>n</sub> H <sub>2n+2</sub> .....	—	—	1.53	1.25
Percentage composition):				
Ammonia and H <sub>2</sub> S .....	—	5.5	7.9	3.5
.....	60.0	38.1	58.9	72.4
.....	10.5	11.0	12.8	12.4
Saturated hydrocarbons.....	1.9	0.9	0.8	0.9
Saturated hydrocarbons .....	5.3	4.5	2.2	3.2
Hydrogen .....	0.0	—	—	—

A slight amount of colorless oil was observed in the tube, although  
distillation there is indicated to be no tar.

TABLE XV.--PRODUCTS OF HEATING COAL, AT 350° C. (662° F.).

Experiment No. ....	650 (Pittsburgh)		674 (New River)		48 Illinois		43 Wyoming	
	63	74*	69	66	66	67	72*	67
Weight of coal (air-dry) .....	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Duration of test (hours) .....	13.0	239.0	7.0	13.5	7.0	7.0	234.0	7.0
Total volatile (without moisture) .....	5.90	12.93	1.87	7.95	15.00	15.00	22.97	15.00
Tar (per cent.) .....	4.28	8.15	0.66	3.08	5.52	5.52	5.92	5.52
Water of decomposition (per cent.) .....	1.12	2.94	0.88	3.68	6.32	6.32	11.07	6.32
Gas (cc. per cent.) .....	0.50	1.84	0.33	1.19	3.16	3.16	5.98	3.16
Gas (cc. per 100 grams) (for cubic feet per ton divide by 3.1) .....	449.0**	1,891.0	256.0	937.0	2,342.0	2,342.0	4,890.0	2,342.0
Ammonia and H <sub>2</sub> S .....	21.0	111.0	15.0	37.0	232.0	232.0	334.0	232.0
CO <sub>2</sub> .....	73.0	117.0	104.0	336.0	1,142.0	1,142.0	1,812.0	1,142.0
CO .....	23.0	71.0	24.0	87.0	358.0	358.0	780.0	358.0
Unsaturated hydrocarbons, etc. ....	44.0	196.0	8.0	67.0	107.0	107.0	286.0	107.0
Saturated hydrocarbons, (C <sub>n</sub> H <sub>2n+2</sub> ) .....	229.0	1,235.0	41.0	307.0	367.0	367.0	1,287.0	367.0
Hydrogen .....	20.0	138.0	9.0	32.0	19.0	19.0	287.0	19.0
Value of <i>n</i> in C <sub>n</sub> H <sub>2n+2</sub> .....	1.57	1.52	1.75	1.60	1.49	1.49	1.46	1.49
Percentage composition of gas:								
Ammonia and H <sub>2</sub> S .....	4.7	5.8	5.9	4.0	9.9	9.9	7.0	9.9
CO <sub>2</sub> .....	16.2	6.2	40.1	35.7	48.7	48.7	37.8	48.7
CO .....	5.1	4.1	9.1	9.3	15.3	15.3	16.3	15.3
Unsaturated hydrocarbons .....	9.8	10.6	3.1	7.2	4.6	4.6	6.0	4.6
Saturated hydrocarbons .....	51.0	65.9	16.0	32.7	15.7	15.7	26.9	15.7
Hydrogen .....	4.5	7.4	3.5	3.4	0.8	0.8	6.0	0.8

\* Continuous long-time test; for detailed data of successive gas fractions see tables 16-17 following.  
 \*\* In the first 6½ hours of this test 271 cc. of gas were obtained, of which 24.2 per cent. was CO<sub>2</sub>, 7.2 per cent. CO, and 2.5 per cent. hydrogen.

TABLE XVI. — PRODUCTS OF CONTINUOUS LONG-TIME HEATING OF PITTSBURGH COAL. (650) AT 350° C. (662° F.), (SUCCESSIVE GAS FRACTIONS).

Experiment No. 74	a	b	c	d	e	f	g	Total
Duration (hours) .....	1.0	22.0	32.0	40.0	27.0	45.0	72.0	239.0
Mean temperature .....	25° to 350°	354°	353°	349°	351°	350°	351°	--
Gas yield (cc. per 100 grams) .....	113.0	655.0	371.0	229.0	124.0	157.0	242.0*	1,891.0
Ammonia and H <sub>2</sub> S .....	13.0	39.0	19.0	11.0	16.0		13.0	111.0
CO <sub>2</sub> .....	53.0	38.0	9.0	5.0	5.0		5.0	115.0
CO .....	47.0		8.0	5.0	5.0		5.0	70.0
Unsaturated hydrocarbons .....	75.0		42.0	25.0	30.0		25.0	197.0
Saturated hydrocarbons (C <sub>n</sub> H <sub>2n-2</sub> ) .....	445.0		264.0	167.0	201.0		158.0	1,235.0
Hydrogen .....	42.0		27.0	17.0	23.0		29.0	138.0
Value of n in C <sub>n</sub> H <sub>2n+2</sub> .....	1.62		1.51	1.47	1.45		1.42	—
Percentage composition of gas :								
Ammonia and H <sub>2</sub> S .....	11.2	6.0	5.20	4.65	5.60		5.35	5.80
CO <sub>2</sub> .....	47.3	5.8	2.55	2.20	1.80		2.20	6.20
CO .....	6.12		2.15	2.30	1.80		2.20	4.10
Unsaturated hydrocarbons .....	9.71		11.35	10.75	10.55		10.45	10.60
Saturated hydrocarbons .....	57.84		71.20	72.90	71.45		65.10	65.85
Hydrogen .....	5.45		7.10	7.30	8.20		12.10	7.45

\* Rate had remained uniform during last 117 hours at about 3.4 cc. per hour per 100 grams.

TABLE XVII.—PRODUCTS OF CONTINUOUS LONG-TIME HEATING OF WYOMING COAL (43) AT 350° C. (662° F.),  
(SUCCESSIVE GAS FRACTIONS).

Experiment No. 72	a	b	c	d	e	f	g	Total
Duration (hours).....	1.0	22.0	31.0	41.0	24.0	26.0	89.0	234.0
Mean temperature.....	25° to 350°	346°	342°	348°	351°	346°	350°	—
Gas yield (cc. per 100 grams).....	1,539.0	1,734.0	442.0	449.0	221.0	144.0	294.0*	4,890.0*
Ammonia and H <sub>2</sub> S.....	98.0	173.0	30.0	16.0	7.0	7.0	11.0	334.0
CO <sub>2</sub> .....	1,030.0	542.0	75.0	71.0	53.0	53.0	42.0	1,812.0
CO.....	244.0	302.0	67.0	68.0	53.0	53.0	47.0	780.0
Unsaturated hydrocarbons.....	35.0	132.0	43.0	39.0	22.0	22.0	15.0	286.0
Saturated hydrocarbons (C <sub>n</sub> H <sub>2n+2</sub> ).....	103.0	487.0	177.0	193.0	167.0	167.0	158.0	1,287.0
Hydrogen.....	5.0	49.0	40.0	54.0	60.0	60.0	79.0	287.0
Value of $n$ in C <sub>n</sub> H <sub>2n+2</sub> .....	1.49	1.59	1.49	1.39	1.30	1.30	1.26	—
Percentage composition of gas:								
Ammonia and H <sub>2</sub> S.....	6.40	9.95	6.70	3.55	1.95	1.95	2.95	6.9
CO <sub>2</sub> .....	66.90	31.25	16.90	15.90	14.40	14.40	11.65	37.1
CO.....	15.85	17.40	15.10	15.15	14.45	14.45	13.10	16.0
Unsaturated hydrocarbons.....	2.30	7.60	9.80	8.60	5.90	5.90	4.15	6.0
Saturated hydrocarbons.....	6.80	28.05	40.00	43.00	45.80	45.80	43.80	26.3
Hydrogen.....	0.30	2.85	9.05	12.00	16.50	16.50	21.80	6.0

\* The gas obtained during the last 15 hours of the run was lost by an accident; for the preceding 24 hours the rate had been about 4 cc. per hour.

TABLE XVIII.—PRODUCTS OF HEATING COAL AT 450° C. (842° F.)

	650 (Pitts- burgh)	674 (New River)	48 (Illin- ois)	43 (Wyom- ing)
Experiment No. ....	73	71	75	76
Duration (hours).....	8.5	9.0	9.5	10.0
Weight of coal (air-dry) ....	5.0	5.0	5.0	5.0
Total volatile (without mois- ture) .....	21.07	12.18	20.82	29.47
Tar, per cent.....	12.76	6.08	7.73	8.17
Water of decomposition, (per cent) .....	4.30	2.30	8.29	12.64
Gas (per cent. by weight) ...	4.01	3.80	4.80	8.66
Gas (cc. per 100 grams coal).	4,694.0	5,498.0	5,621.0	8,194.0
Gas in first 3 hours of run ...	4,385.0*	4,410.0	4,370.0	7,426.0**
Total gas :				
Ammonia and H <sub>2</sub> S (cc.).	138.0	48.0	104.0	432.0
CO <sub>2</sub> .....	174.0	223.0	533.0	2,128.0
CO .....	187.0	130.0	483.0	1,426.0
Unsaturated hydrocar- bons .....	352.0	334.0	320.0	394.0
Saturated hydrocarbons (C <sub>n</sub> H <sub>2n+2</sub> ) .....	3,100.0	3,551.0	3,158.0	2,647.0
Hydrogen .....	653.0	1,168.0	935.0	1,129.0
Value of <i>n</i> in C <sub>n</sub> H <sub>2n+2</sub> ...	1.37	1.21	1.30	1.31
Percentage composition of gas :				
Ammonia and H <sub>2</sub> S.....	2.94	0.87	1.85	5.27
CO <sub>2</sub> .....	3.71	4.05	9.48	25.95
CO.....	4.00	2.36	8.59	17.40
Unsaturated hydrocar- bons .....	7.50	6.07	5.70	4.79
Saturated hydrocarbons.	66.00	64.56	56.18	32.28
Hydrogen .....	13.98	21.24	16.64	13.76
* First 6 hours.				
** First 5 hours.				

No. 43. Dietz No. 2 mine, Sheridan County, Wyoming, bed No. 2, mine sample, 5 years since mining.

All the samples had been kept since mining in closed containers, as ¼-in. to ½-in. lumps.

#### *Summary of Results.*

The results obtained in experiments at 250°, 350° and 450° C. (482°, 662°, and 842° F.) are presented in Tables 14-18.

and graphically in Figs. 9-13. Most of the tests were run for a period not exceeding 13 hours, *i. e.*, only during the time of the principal evolution of volatile matter. In addition, however, two coals were run for long-continued periods (230-240 hours) at 350° C. (662° F.) in order

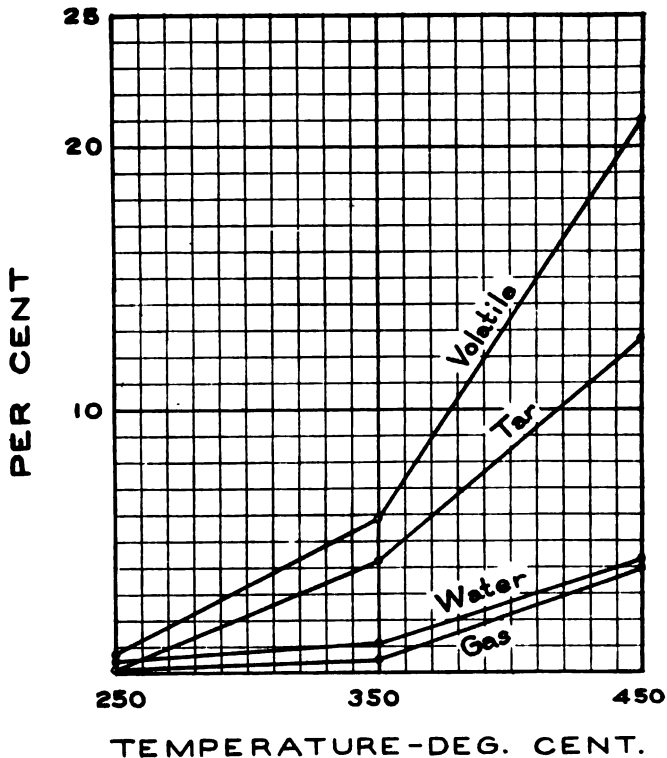


Fig. 9a.—Percentage yields of tar, water, gas, and total volatile by heating Pittsburgh coal in vacuo at low temperatures.

to determine the nature and rate of the very slow decompositions which go on after the principal decomposition is over. Another long-continued test was made in which the Pittsburgh coal was heated for 240 hours at 350° C. and then for 191 hours at 450° C. The results of this latter experi-

were obtained too late to be included in detail in this

referring to Fig. 9 which shows the composition of the volatile matter at these low temperatures: We may note the proportion of tar in the volatile from the Pittsburgh coal and the high proportion of water in that from the Western

The Western coals decompose more easily than the Eastern, and at the lower temperatures they yield more combustible volatile products; at 450° C. (842° F.), however, the

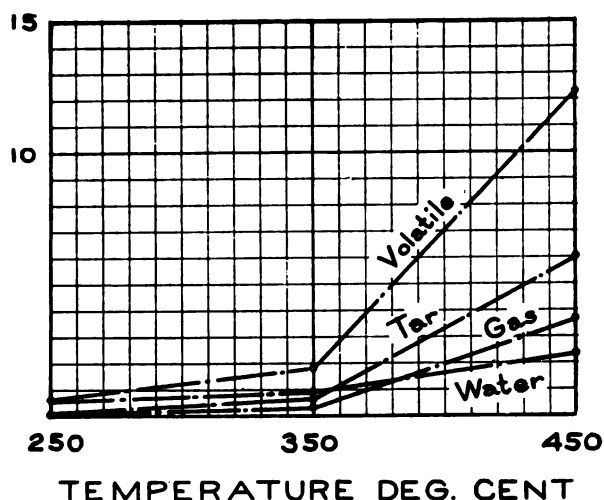


Fig. 9.—Percentage yields, tar, water, gas, and total volatile by heat-treatment of New River (West Virginia) coal in vacuo at low temperatures.

Pittsburgh type produces more combustible volatile matter than the others, its total volatile, though less in amount, being largely made up of combustible matter than that of the Western coals.

In the case of the Pittsburgh coal, we see that while the gas at 450° C. (842° F.) is only about 15 per cent. of what is usually obtained by high-temperature carbonization, the tar is 250 per cent. of the usual high-temperature yield, and water, moreover, is largely (*i. e.*, about 80 per cent.) made



up of paraffin hydrocarbons. We obtain by carbonization at 450° C. (842° F.) about 65 per cent. of the usual high-temperature volatile matter, two-thirds of this yield consisting of paraffin hydrocarbons, mostly liquid under ordinary condi-

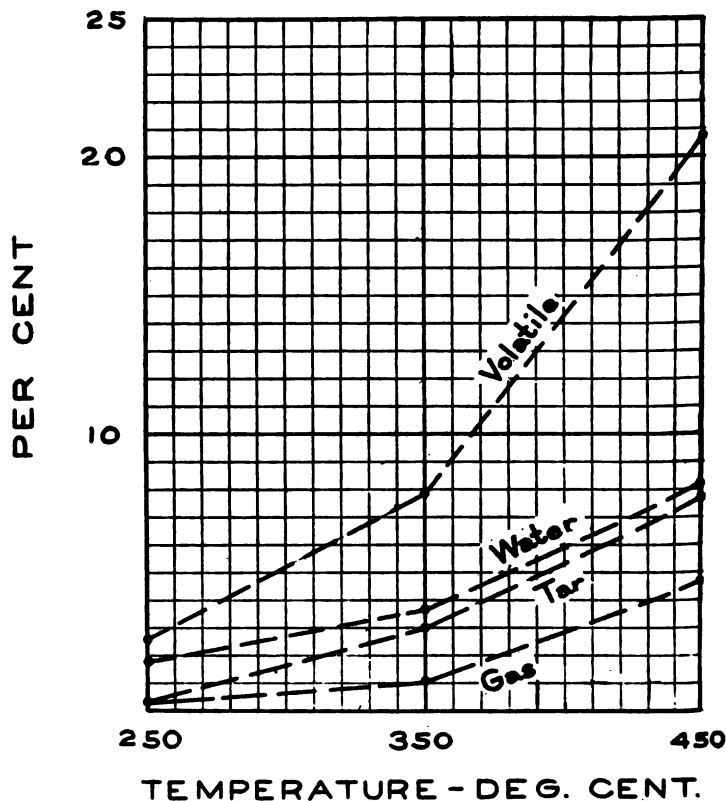
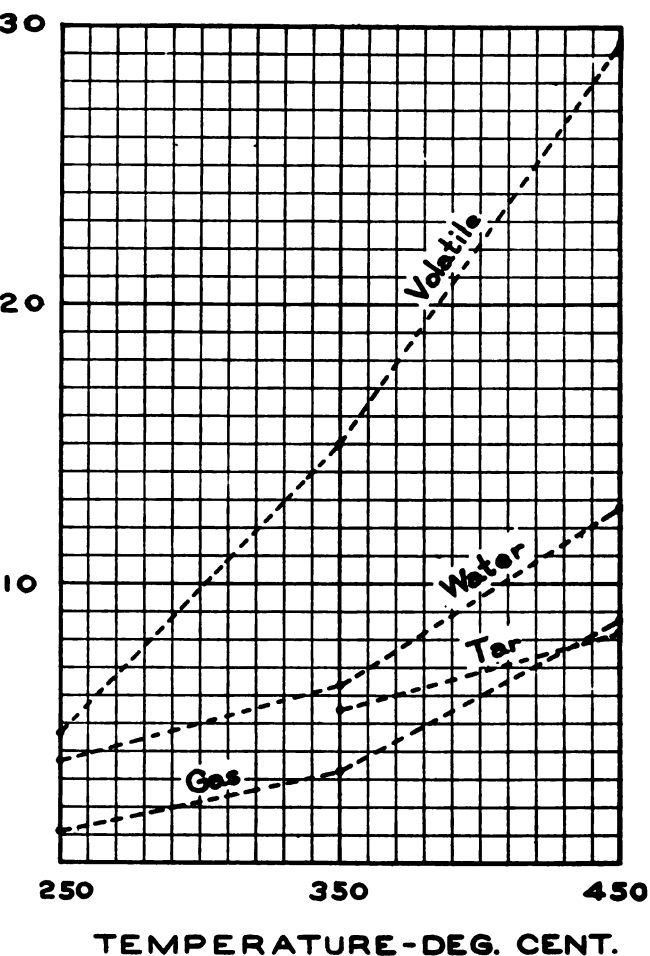


Fig. 9c.—Percentage yields, tar, water, gas, and total volatile by heating Franklin Co. (Illinois) coal in vacuo at low temperatures.

tions. The primary decomposition products appear to be principally the complex, easily liquefiable paraffin hydrocarbons, with smaller amounts of water,  $\text{CO}_2$  and hydrogen.

From Fig. 10, we see the great predominance of hydrocarbons in the low-temperature gases from an Appalachian gas

Although it is also to be noted that the percentage of much higher in the earliest gases than in those formed



---Percentage yields, tar, water, gas, and total volatile by heat-  
Wyoming sub-bituminous coal in vacuo at low temperatures.

ewhat higher temperatures. In other words, the small  
t of  $\text{CO}_2$ -producing substance which is present decom-

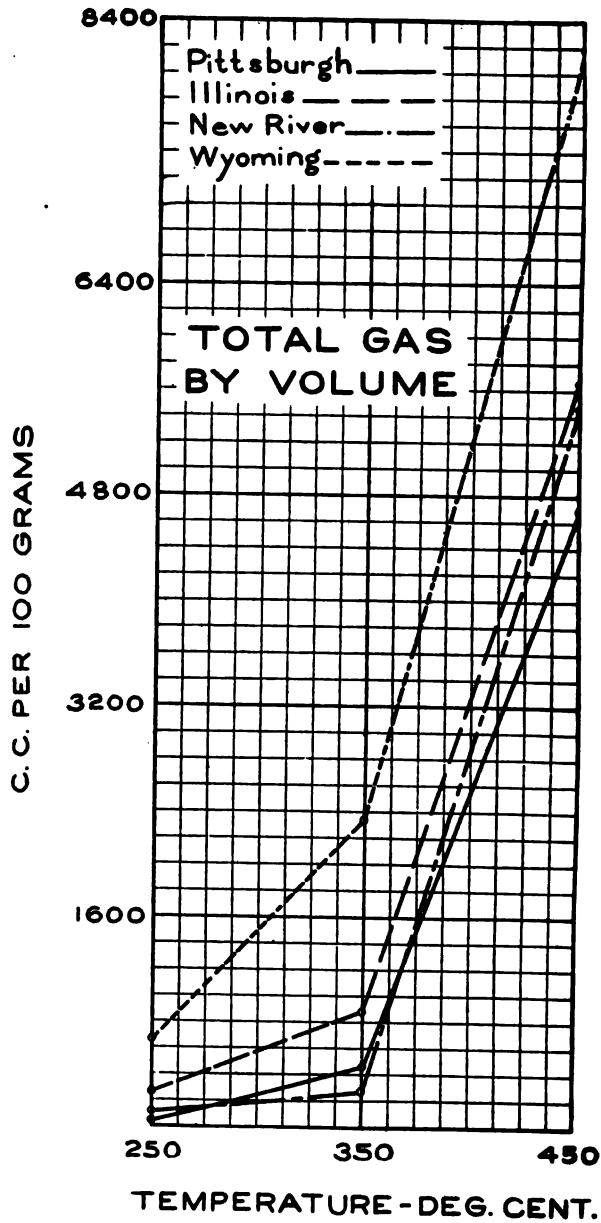


Fig. 9e.—Yields of gas, by volume, heating different coals in vacuo at low temperatures (cc. per 100 g. divided by 3.1 equals cu. ft. per ton.)

very easily. Hydrogen is formed in appreciable quantity at 350° C. (662° F.) but very slowly. Unfortunately, a satisfactory comparison of the different coals with one another cannot be made from the data at 350° C. since the tests were not all run for the same period of time.

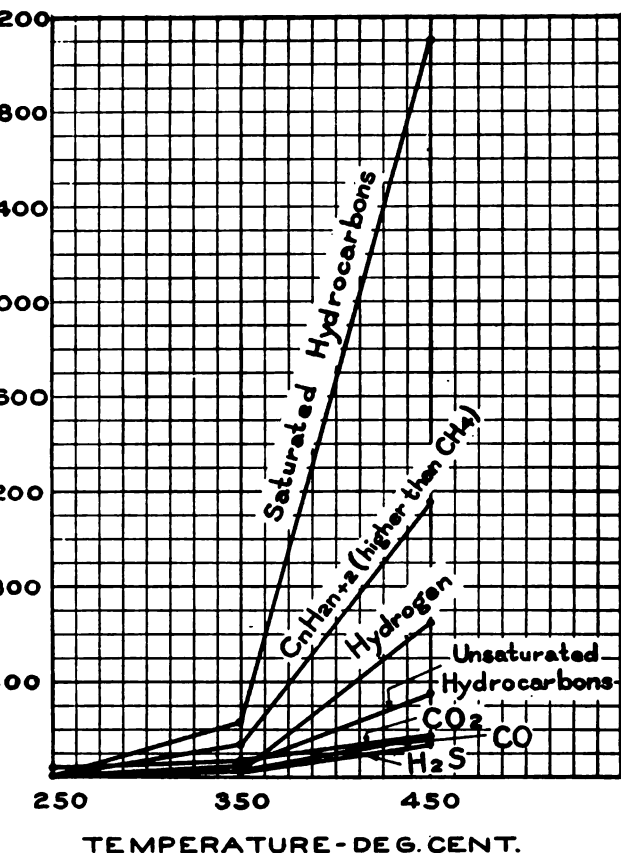


Fig. 11.—Quantities of various gases obtained from Pittsburgh coal in vacuo at low temperatures.

Figs. 11, 12 and 13 show the rate of evolution of different gases during long-continued heating of the coal at 350° C.

(662° F.). The decompositions producing hydrocarbons and hydrogen evidently progress very slowly at this temperature and continue for a long time. During the first 24 hours of the 10-days period of heating the coal, only about  $\frac{1}{2}$  of the

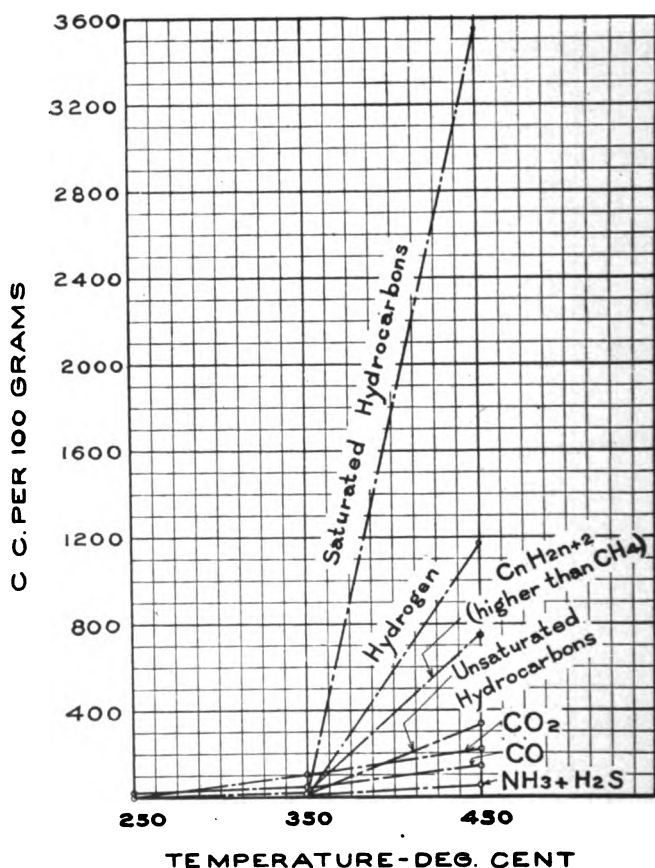


Fig. 10b.—Quantities of various gases obtained from New River (W. Va.) coal in vacuo at low temperatures.

final yield of hydrocarbons and  $\frac{1}{5}$  of the hydrogen were produced. Fig. 13 (based on results with the Wyoming coal) shows for each constituent of the gas the rate at which it is

ed at this low temperature, *i. e.*, the percentage of its production obtained during each successive interval of . The reactions producing  $\text{CO}_2$ ,  $\text{CO}$ , and  $\text{H}_2\text{S}$  are evidently not the same as those producing hydrocarbons and

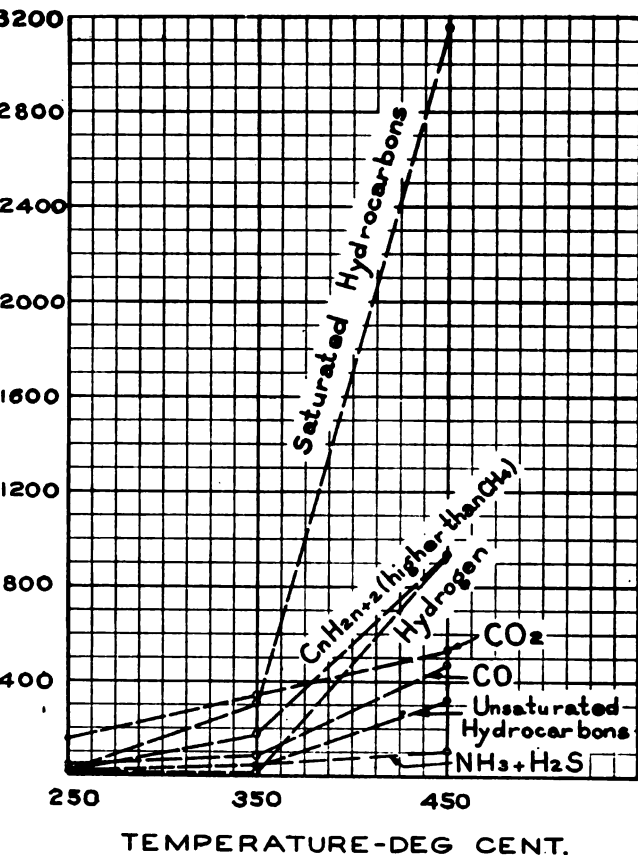


Fig. 10. — Quantities of various gases obtained from Franklin Co. (Illinois) coal in vacuo at low temperatures.

gen, and they evidently proceed with greater ease at this temperature.

may summarize, as follows, the information gained as to

the primary decomposition reactions taking place when coal is heated.

1. More than two-thirds of the organic substance of coal is decomposable below  $500^{\circ}\text{C}$ . ( $932^{\circ}\text{F}$ .); there is a variation among the different kinds of coal in their ease of decomposition, those of the Appalachian field, because of their greater

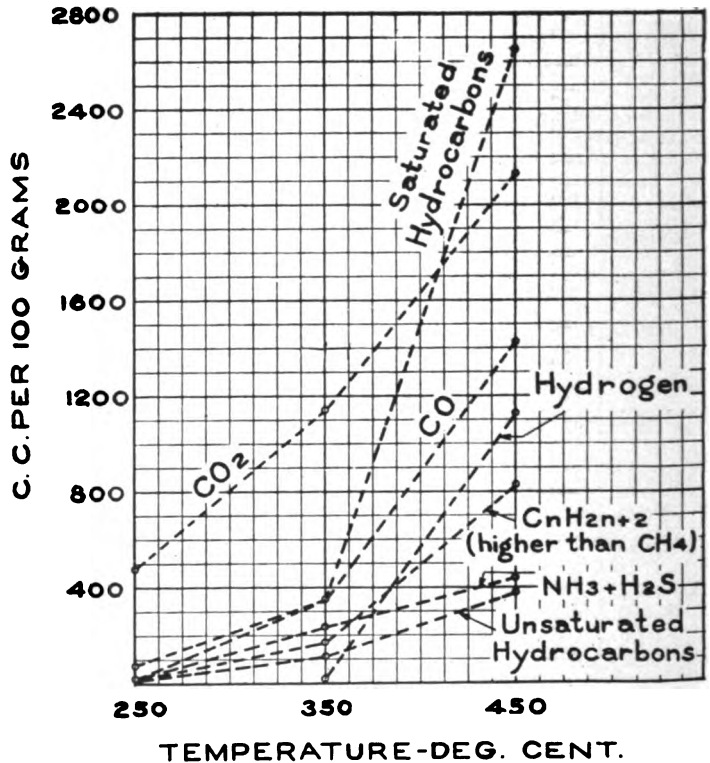


Fig. 10d.—Quantities of various gases obtained from Wyoming sub-bituminous coal in vacuo at low temperatures.

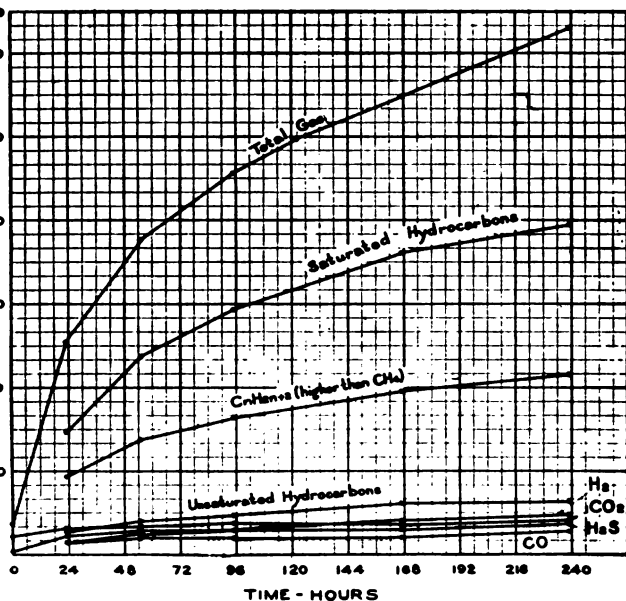
maturity being less easily and rapidly broken down than the younger coals of the middle western and western fields.

2. The first decomposition occurring in any type of coal as the temperature is raised is the breaking down of certain

and bearing substances related to cellulose, whereby chiefly of decomposition,  $\text{CO}_2$  and  $\text{CO}$  are produced.

With a coal of the Pittsburgh type this decomposition is somewhat below  $250^\circ \text{C}$ . ( $482^\circ \text{F}$ .), while with the other coals, notably the sub-bituminous type, it begins at a lower temperature.

Other decomposition processes, producing paraffin hydrocarbons both liquid and gaseous, begin at an early stage, but



Quantities of various gases in successive intervals of time during long-continued heating of Pittsburgh coal at  $350^\circ \text{C}$ . ( $662^\circ \text{F}$ .).

and very slowly at the lower temperatures. In coals of Pittsburgh type this decomposition soon becomes the pre-  
 vailing one, between 60 and 70 per cent. of the total vola-  
 products at  $450^\circ \text{C}$ . ( $842^\circ \text{F}$ .) being paraffin hydrocarbons.  
 On the other hand, in the decomposition of a coal of the  
 ligning sub-bituminous type, the "water- $\text{CO}_2$ -yielding"  
 process remains the principal one up to at least  $450^\circ \text{C}$ .



(842° F.), the products at that temperature containing 60-70 per cent. of water,  $\text{CO}_2$  and  $\text{CO}$ .

6. The gaseous paraffin hydrocarbons produced at 350° C.

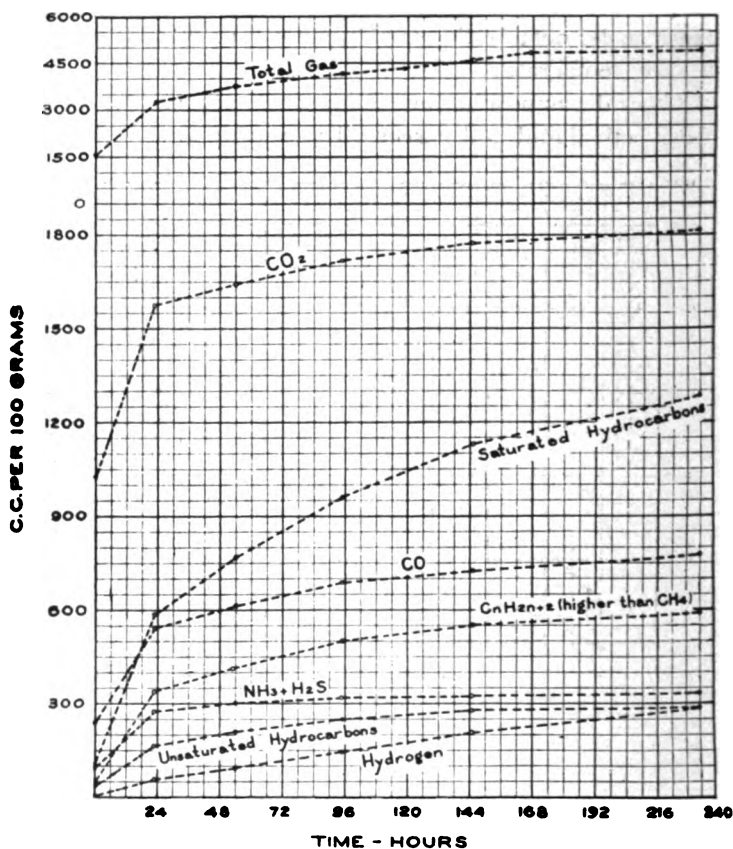


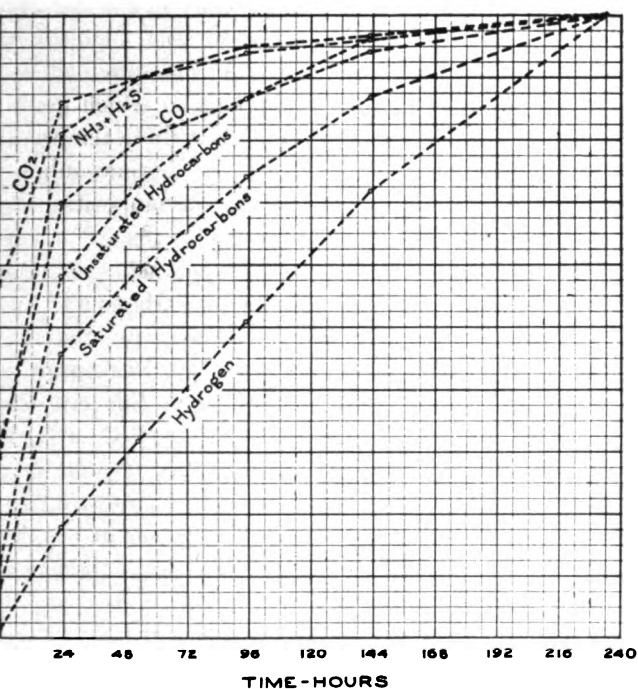
Fig. 12.—Quantities of various gases in successive intervals of time during long-continued heating of Wyoming sub-bituminous coal at 350° C. (662° F.).

(662° F.) from Pittsburgh coal are more than 50 per cent. constituted of members higher than  $\text{CH}_4$ ; at 450° C. (842° F.) about one-third is so constituted.

7. Thermal decomposition of the primary volatile products

place quickly and easily at temperatures of  $1,350^{\circ}\text{F.}$  above. The liquid hydrocarbons in the tars undergo such decomposition more easily than the gaseous products and thus, below  $1,350^{\circ}\text{F.}$ , methane, hydrogen, ethylenic hydrocarbons, and carbon.

At  $450^{\circ}\text{C. (842^{\circ}\text{F.})}$  a tar yield of nearly 13 per cent. is obtained from Pittsburgh coal, which is much greater



—Rate of evolution of the different gases during long-continued carbonization of Wyoming coal at  $350^{\circ}\text{C. (662^{\circ}\text{F.})}$  showing for each time interval the percentage of the total production of each gas.

The customary tar yield from this type of coal in high-temperature carbonization. The paraffin hydrocarbons contained in this tar, ordinarily in high-temperature carbonization, are heated on heated surfaces and break up into  $\text{CH}_4$ ,  $\text{H}_2$ ,  $\text{C}_2\text{H}_4$ , etc., naphthalene, etc., and free carbon.

9. Water of decomposition is produced in the destructive distillation of coal principally below  $500^{\circ}\text{C}$ . ( $932^{\circ}\text{F}$ .). The water vapor in passing out of a heated retort during high-temperature carbonization may enter into thermal reactions with  $\text{CO}_2$ ,  $\text{CO}$ , hydrocarbons, or free carbon. At  $450^{\circ}\text{C}$ . ( $842^{\circ}\text{F}$ .) water amounts to  $\frac{1}{5}$  of the total volatile matter from Pittsburgh coal.

10. Hydrogen is produced appreciably in the decomposition of coal at  $350^{\circ}\text{C}$ . ( $662^{\circ}\text{F}$ .) and in such quantity by long heating at  $450^{\circ}\text{C}$ . ( $842^{\circ}\text{F}$ .) that it constitutes 14 to 21 per cent. of the total gas. The decomposition which gives rise to hydrogen is, however, extremely slow at these temperatures.

11. Sulphurous gases ( $\text{H}_2\text{S}$ ,  $\text{CS}_2$ , or organic sulphur compounds) are produced easily in the decomposition of coal; they begin to be formed below  $250^{\circ}\text{C}$ . ( $482^{\circ}\text{F}$ .) and as the temperature rises their production approaches its maximum more rapidly than does that of the hydrocarbons and hydrogen.

12. Coals of approximately equal volatile matter but of different oxygen content (*e. g.*, Nos. 650, Pittsburgh, and 48 Illinois) yield volatile products of very different character. The coal of higher oxygen gives at  $450^{\circ}\text{C}$ . ( $842^{\circ}\text{F}$ .) a greater amount of water of decomposition (about in proportion to its relative content of oxygen), a less amount of tar, and a somewhat greater volume of gas, the excess of gas, however, consisting largely of  $\text{CO}_2$  and  $\text{CO}$ . It may be laid down as a general rule that the higher the oxygen in the coal the less will be the proportion of hydrocarbons and tar in the volatile matter.

#### EXPERIMENTS ON SECONDARY THERMAL DECOMPOSITION OF THE VOLATILE PRODUCTS.

We may consider now briefly the methods used in showing qualitatively the thermal decomposition of the entire volatile matter, as compared to that of the gas alone.

First, the effect of superheating the gas alone was investigated. Gas obtained by heating Illinois coal (48) at  $450^{\circ}\text{C}$ . ( $842^{\circ}\text{F}$ .) was superheated by passing 80-90 cc. slowly back

forth through a quartz tube, 10 in. long and 0.16 in. in diameter, heated to 750° C. (1,382° F.) and to 800° C. (1,472° F.).

After 10 passes, the original gas was altered in such manner that it contained relative quantities of the different ingredients shown in columns (2) and (3) of the table below, column (1) being the original gas composition.

	(1) (Original)	(2) (750° C.)	(3) (800° C.)
Volume, cc.....	100.0	108.6	113.9
Ammonia and H <sub>2</sub> S.....	1.80	1.10	0.75
.....	11.50	11.55	11.55
.....	8.35	8.60	9.55
Saturated hydrocarbons .....	6.60	11.55	15.40
Unsaturated hydrocarbons (C <sub>n</sub> H <sub>2n-2</sub> ).....	58.05	61.60	57.15
Hydrogen.....	11.85	11.95	17.65
Amount of n in C <sub>n</sub> H <sub>2n-2</sub> .....	1.365	1.215	1.08

Finally, to show the decomposition of the volatile products as a whole (gas, water and tar) obtained at 450° C. (842° F.), the coal was distilled at 450° C. (842° F.), subjecting the entire volatile matter to 750° C. (1,382° F.) by means of a secondary heater above the coal. The apparatus shown in Fig. 14 was used. *a* is a quartz tube, 20 mm (4/5 in.) in diameter and 375 mm. (15 in.) long, in the bottom of which were placed 3 grams of the Pittsburgh coal (650). The coal was heated 2 hours at 450° C. by means of the molten-nitrate bath, while the tube above the coal was heated at 750° C. (1,382° F.) for 15 cm. (6 in.) by a cylindrical electric furnace. In order to determine the effect of vacuum in drawing away the products from the heated vessel and thus reducing secondary decomposition, the tests with secondary heating were run both in vacuo and at atmospheric pressure. A gas-collecting reservoir with leveling bulb was attached at *b*. The apparatus was evacuated before beginning to heat the coal, and the vacuum pump then closed off. When the pressure of the evolved gases had risen to normal (in about 1/2 hour) it was maintained uniform by means of the leveling bulb. Yields of gas, tar and water were not determined, the tube C serving

merely to keep condensable products out of the pump. The

To vacuum pump

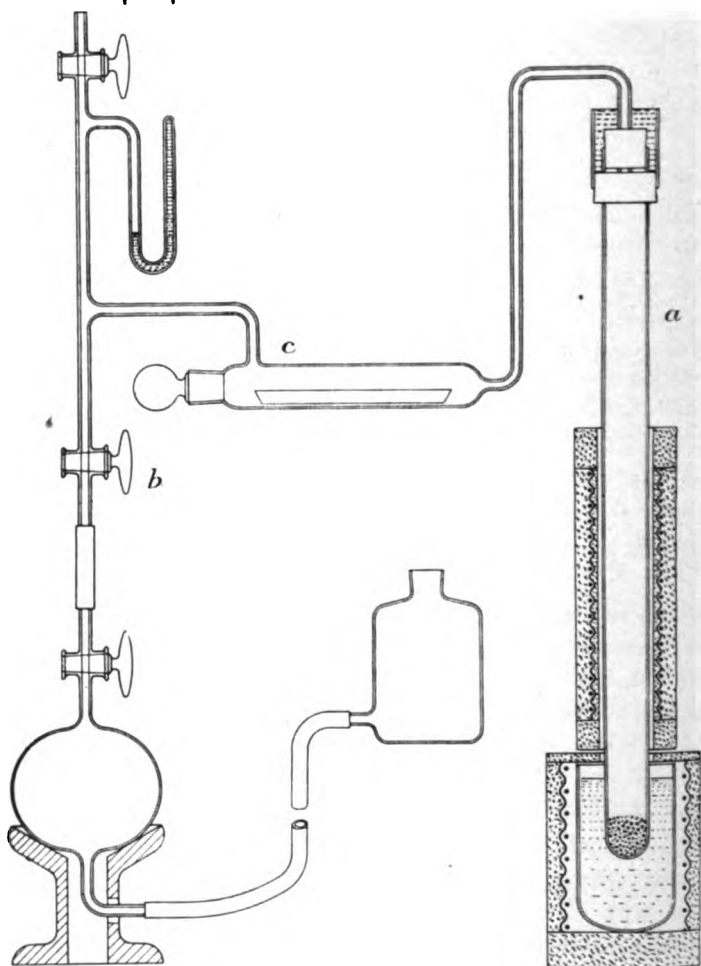


Fig. 14.—Apparatus for distilling coal at low temperatures and superheating the volatile products.

gases evolved during three different sets of conditions were as follows:

TABLE XIX.—EXPERIMENTS SHOWING SECONDARY DECOMPOSITION OF VOLATILE PRODUCTS AT 750° C. (1,382° F.)

	Yield of gas (cc. per 100 grams of coal)		
	In vacuo without secondary heating	In vacuo with secondary heating	At normal pressure with secondary heating
Coal 650 (Pittsburgh) distilled at 450° C. (842° F.); volatile products heated at 750° C. (1,382° F.)			
H <sub>2</sub> S and ammonia .....	160.0	220.0	155.0
CO <sub>2</sub> .....	160.0	138.0	253.0
CO .....	127.0	480.0	687.0
Unsaturated hydrocarbons, etc. ....	335.0	1,287.0	857.0
Saturated hydrocarbons (C <sub>n</sub> H <sub>2n+2</sub> ) ..	2,287.0	3,450.0	5,253.0
Hydrogen .....	207.0	1,063.0	2,007.0
Total (cc. per 100 grams) .....	3,276.0	6,638.0	9,212.0
Total (cubic feet per pound) .....	0.528	1.07	1.486
B. t. u. in gas per pound of coal ..	605.0	1,156.0	1,320.0
Value of $\pi$ in C <sub>n</sub> H <sub>2n+2</sub> .....	1.510	1.430	1.045
CH <sub>4</sub> (assuming only CH <sub>4</sub> and C <sub>2</sub> H <sub>6</sub> present) .....	1,120.0	1,967.0	5,017.0
C <sub>2</sub> H <sub>6</sub> (assuming only CH <sub>4</sub> and C <sub>2</sub> H <sub>6</sub> present) .....	1,167.0	1,483.0	237.0

The tube, where superheated, was heavily coated with deposited carbon. Even in the experiment without secondary heating, a very evident blackening or partial carbonization of the tar was noticed where it had run down the walls into the heated part (at not above 450° C.). The ease with which some of the primary volatile products decompose by secondary heating is thus shown. A comparison of the data in columns 1 and 3 above, shows the large increase in production of hydrogen and methane by secondary heating, as well as in unsaturated hydrocarbons and CO. Comparison of columns 2 and 3 shows that under vacuum there occurs by secondary heating not as great an increase in methane and hydrogen as under normal pressure, but a larger increase of unsaturated hydrocarbons. The production of the latter, therefore, together with hydrogen and probably carbon, seems to be one of the easiest and most rapid of the secondary reactions at this temperature. The increase in CO by secondary heating indicates the interaction of water vapor with volatile carbonaceous products.

The above experiments on secondary decomposition are

preliminary and not intended for the deduction of quantitative laws of the thermal decomposition of gases. A recent thermodynamic and quantitative experimental investigation of these laws by Whitaker and Rittman<sup>14</sup> is of interest in this connection.

*Importance of Further Research in This Field.*

Since it is evident that the yield and composition of gas from coal distillation, as well as the yield of by-products therefrom depends very largely on the degree of superheating which the products, both tars and gases, undergo before leaving the retort, we see the importance of careful experiments to determine the effect of temperature, pressure and duration of time on the secondary reactions of the tars and gases. These studies should be based on the laws of physical chemistry, especially those of equilibria relations.

*Experiments to Show that Coal is Decomposed at 250° C. (482° F.) Under Atmospheric Pressure.*

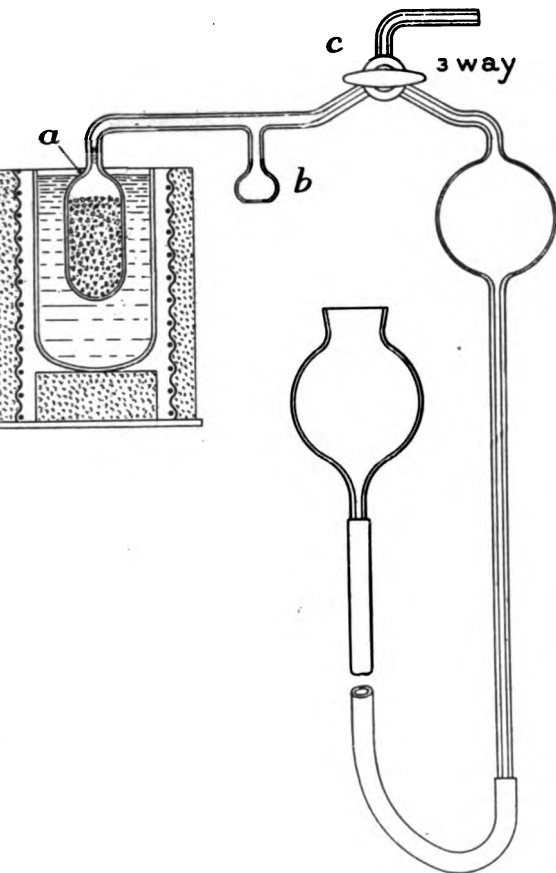
The bulb A (Fig. 15) was filled with 15 grams of air-dry coal, and by means of the mercury reservoir with leveling bulb, and the 3-way cock *c*, the air was exhausted from the apparatus in order to dry the coal and remove occluded gases. To facilitate this *a* was heated to 100° C. in boiling water under a vacuum of 2 mm. of mercury, placing a tube of  $P_2O_5$  in connection as a drying agent. After drying the coal in this manner  $\frac{1}{2}$  to 1 hour, pure nitrogen at atmospheric pressure was admitted, and the coal brought to 250° C. (482° F.). As the gas pressure increased the leveling bulb was lowered so as to maintain even pressure. After heating for the desired period, *a* was allowed to cool, the bulb *b* was cooled in ice so as to reduce the vapor pressure of water, the gas was pumped out, measured and analyzed.

(a) Coal 650 (Pittsburgh), 15 grams, heated 4 hours at 250° C. (482° F.); increase in gas volume, 8.4 cc., of which 3.9 cc. (46 per cent.) was  $CO_2$ , and in which higher paraffin

<sup>14</sup> Jour. Ind. Eng. Chem., 6, 383, May, 1914.

carbons were clearly indicated on combustion. Water composition was noted by condensation in bulb *b* and connecting tubes. Compare Table 14 for test in vacuo.

Coal (Wyoming), 15 grams, heated  $\frac{1}{2}$  hour at  $250^{\circ}$   $2^{\circ}$  F.); increase in gas volume, 78 cc., of which 70 cc.



15.—Apparatus used in heating coal at low temperatures under normal pressure in nitrogen.

er cent.) was  $\text{CO}_2$  and in which combustible gases were t sufficient to produce 7.7 cc. of  $\text{CO}_2$  on burning.



Compare Table 14, page 259, for test on this coal in vacuo. where an amount of gas equivalent to 99 cc. from 15 grams was produced in 7 hours' heating at 250° C. Water of decomposition was produced in considerable quantity.

#### GENERAL CONCLUSIONS.

##### *The Primary Decomposition Processes.*

A high-grade bituminous coal of the gas-making type decomposes by heat primarily into paraffin hydrocarbons and a completely altered non-volatile residue, with small quantities of water,  $\text{CO}_2$  and  $\text{CO}$ . The latter products, though small, are the first produced, and from other types of coal they are produced in greater relative quantities than from the gas-coal type. Complex and varied secondary reactions induced by superheating the hydrocarbons, water vapor and  $\text{CO}_2$  are of very great importance in industrial high-temperature carbonization.

The products of low-temperature carbonization (at 800°–900° F.) of a coal of the Pittsburgh type on an industrial scale would consist of a rich gas amounting to about 0.6–0.7 cu. ft. per pound of coal, and of a large yield of oils, or tar, 10–12 per cent. of the coal, made up principally of paraffin hydrocarbons, very low in benzene and naphthalene derivatives and practically devoid of free carbon. The gas would contain 6–7 per cent. of unsaturated hydrocarbons and 20–25 per cent. of ethane and its higher homologues, having therefore a high calorific and illuminating value. The tar could be either redistilled or subjected to cracking processes so as to produce light oils—gasoline substitutes—whose yield would be greater than, and probably at least double, that obtained by high-temperature carbonization.

The possibility is suggested that low-temperature carbonization might be utilized in gas manufacture as an enriching process by passing through the low-temperature retorts a large relative quantity of a thin gas such as blue water gas, sweeping out the light oil vapors which are primarily liberated at these

temperatures. The utilization of inferior coals for gas may in this manner, possibly, be facilitated.

*The Constitution of Coal.*

On the experimental results of low-temperature decomposition in vacuo above recorded, the following hypothesis is proposed for the constitution of coal.

Kinds of coal consist of cellulosic degradation products more or less altered by the processes of aging, together with derivatives of resinous substances, vegetable waxes, etc., in different proportions, also more or less altered. These substances vary in number and closely graded into one another in their nature and composition. They all undergo decomposition by a certain degree of heat, some, however, decomposing more readily than others at the lower temperatures. The less altered cellulosic derivatives decompose more easily than the more altered resinous derivatives and also more easily than the resinous derivatives. The cellulosic derivatives on moderate heating decompose to yield water,  $\text{CO}_2$ , CO and hydrocarbons, giving less of these products the more mature and altered they are. Resinous derivatives, on the other hand, decompose on moderate heating so as to yield principally the paraffin hydrocarbons, with probably hydrogen also as a direct decomposition product.

The more mature bituminous coals, having good coking properties, contain a large percentage of resinous derivatives, while their cellulosic constituents have been highly altered. Younger bituminous and sub-bituminous coals are composed of cellulosic derivatives much less altered than in the older coals. They undergo a large amount of decomposition below their fusion point and partly for that reason many of them do not coke.

Blauvelt withdrawing, Mr. A. B. Way, of Everett, took the chair.)

ACTING CHAIRMAN: I take it from Dr. Porter's remarks that he believes there are two kinds of inert volatile sub-

stances, one is of the kind he gave us, and the other is like what some previous investigators have given us. To start the discussion, I will ask the secretary to read a communication we have received from Prof. A. H. White.

PROF. A. H. WHITE (Ann Arbor, Mich.): (Written discussion communicated.) This elaborate investigation confirms the results of previous experimenters in showing that the products which escape from the gas retort in usual practice are not those formed by primary decomposition of the coal, but are secondary products. Distillation of coal at low temperatures will probably never be an industrial process, but its study is of importance as showing the primary products from which the commercial products are derived. The direction of these secondary reactions is fairly well known, but we lack quantitative data, and it is to be hoped that the authors will continue the investigation they have outlined. An interesting practical application of their work is suggested by their long-time tests which showed that gas evolution was slowly proceeding at a practically constant rate even after ten days heating at  $350^{\circ}$  C. Tests reported in 1908 (Destructive Distillation of Coal at Low Temperatures, by A. H. White, F. E. Park and W. A. Dunkley. Proc. Michigan Gas Association, 1908) from the Michigan Gas Association Fellowship showed that the coking constituent of coal was destroyed by heating for six hours to  $500^{\circ}$  C. The continuous evolution of gas now reported as occurring at much lower temperatures suggests that the harmful effects usually ascribed to storage are in reality due to moderate heating of the coal and not to exposure to the weather. The very slight changes which have been observed in the coals which have now been weathered three years at the Gas Experiment Station of the Michigan Gas Association, as well as numerous laboratory tests, support this view.

THE ACTING CHAIRMAN: Can we hear some expression of opinion concerning this paper, or can we have some questions asked pertaining to it? Although Dr. Porter says he is not advancing any methods and does not claim to tell us the commer-

actices we must use, still I think we can find a number of where we might learn from this work, concerning our practice, which we do not know and which we should. Is there anything in the way of discussion?

O. B. EVANS (Philadelphia): I think the Institute be congratulated in having such an able paper presented to it, and that we are fortunate in being able to listen to a clear description of what occurs in low temperature distillation.

While the subject of the primary decomposition of coal may at first glance appeal to the gas works manager as one affording his operating results, nevertheless a little study will show how vitally important may be the result of the further treatment of these products of early distillation.

When ordinary gas coal is heated to 800° F., over half of the volatile matter by weight is driven off while the yield of gas is only 10 per cent. of the total ultimate production. The residue remaining in the coal is of poor quality, and our commercial yields of 5.25 cu. ft. per pound and 13 c. p. flat flame are due in the main to the further decomposition of the products of distillation obtained at low temperatures.

At Philadelphia we have started some experiments along the lines described by Dr. Porter, though on a commercial basis. That is, instead of a scientific analysis of the gases, etc., produced, we have been measuring the yield of gas, tar and ammonia, and determined the calorific and heating value of the gas produced. For such work, it has been necessary to use large samples of coal (about 40 pounds), and this has introduced some complicating factors, so that the results so far obtained, have been but preliminary.

Our indications are, however, that when gas coal is heated to 800° F. there is produced about one cu. ft. of 15 c. p. gas (flat flame) per pound, and about 30 gallons of tar per ton. By superheating this mixture of gas and tar to about 1,400° F. the candle-power is increased to about 30. Further heating of the coal above 1,000 degrees results in the production of

a gas of very low candle-power (less than five) and only about two gallons of tar per ton. These figures seem to indicate very clearly the value of the products of low temperature distillation, and that their proper subsequent heat treatment may be very important.

The table given by Dr. Porter on page 279 is particularly interesting in this connection. I would call your attention, however, to the fact that a higher quantity of unsaturated hydrocarbons ("illuminants") in a gas, does not necessarily mean a higher candle-power gas, since in the usual method of determining these constituents by absorption by bromine or sulphuric acid, a great variety of hydrocarbons of widely different calorific and illuminating values are absorbed.

For example, in water gas the illuminants produced by two different oils may vary from 1,750 to 2,200 B. t. u. per cu. ft., while the variation in candle-power produced may be as much as 40 per cent.

S. R. CHURCH (New York): If I understand Dr. Porter correctly, he considers the primary products to be those produced at temperatures not exceeding 800 or 850° F., and I think he stated that he had not analyzed the tar produced at these temperatures. In commenting on the secondary decomposition products, Dr. Porter placed phenol in the latter group. He referred, however, to Wheeler's finding phenols in tars produced at low temperatures.

Dr. Porter also referred to the tar produced by Parr and Olin, of the University of Illinois. I was fortunate enough to secure some of the tar from Parr and Olin, which they stated was produced at 800° F. from Illinois coal. In this tar I found about 25 per cent. of phenoloid bodies (by extracting the distillate from the tar with caustic soda solution). The distillate from these tars also contained a fairly high percentage of paraffin bodies (which remain unsulphonated after treatment with 37 times normal sulphuric acid).

THE ACTING CHAIRMAN: Dr. Porter, have you anything to say in closing the discussion?

DR. PORTER: I think Prof. White is perfectly correct in saying that the alteration of coking property of coal by slight heating, is probably due to this decomposition other than to oxidation; or, we might say, that it is probably due to both. I do think that oxidation has something to do with it also, but when coal heats spontaneously in a storage pile, even to a moderate degree, as it often does, without taking fire, the coking property is undoubtedly affected very seriously by the slight decomposition due to heat.

Mr. Evans referred to the residue from this low temperature heating as having no tar content in it. Here are one or two samples obtained from coal heated to 450° C. (840° F.) on a somewhat larger scale than we were doing in the experiments described. We recently distilled 150 grams at that temperature and here is a mass of the residue from Pittsburgh coal. Now, by powdering this and heating it to a high temperature, you will get no coking, no adherence of particles, only two tenths of a per cent., a moisture of tar is produced, and the gas is largely hydrogen. That (exhibiting sample bottle and contents) you see is a very porous, friable mass. There (indicating contents of another bottle) is the residue from a non-coking, western coal, its physical appearance being about as it was when we placed it in the retort.

I think possibly there might be developed a test of the coking quality of coal, based on heating at certain definite low temperatures. You can tell almost definitely by the way a coal behaves on low temperature heating, whether it will make good coke.

Here (exhibiting bottle and contents) is a sample of low temperature tar from Pittsburgh coal. It is thin as you see, from the way it pours. A non-coking Utah coal gave a tar of axle grease consistency.

Mr. Church has referred to testing a tar which Prof. Parr made. I am anxious to know the percentage of phenols which was obtained.

We did not analyze our tars, but others have done so with

similar tars. Phenols are evidently present in these low temperature tars as shown by Mr. Church and by Dr. Wheeler (England), and also as indicated by the odor.

The non-coking tar in Utah gives a tar of axle grease consistency.

THE ACTING CHAIRMAN: We are now ready for the last paper on our program, a paper by Mr. W. F. Rittman, of Pittsburgh, upon the subject of "Gas Manufacture from the Point of View of Physical Chemistry."

### GAS MANUFACTURE FROM THE POINT OF VIEW OF PHYSICAL CHEMISTRY.

In past practice, gas manufacture has been primarily an engineering problem, with the chemist a more or less necessary adjunct for the analysis of coal, coke, oxide, etc. The research chemist, who deals with the processes of manufacture and the phenomena of reactions involved, has been looked upon as a burden unwarranted by returns. In view of the present available raw materials for gas manufacture on the one side, and the demands of the public on the other, the advisability of continuing the policy of the past becomes a serious question.

There are few industrial operations which, from the standpoint of physical chemistry are more complex in their nature than the treatment by heat of coal, oil and water in the production of coke, gas, tar, ammonia and cyanogen. In gas manufacture practically all the variables of chemical phenomena are involved. While this fact greatly complicates such industrial problems theoretically and practically, at the same time it greatly enlarges their possibilities; it strongly emphasizes the need of continued scientific research and investigation in connection with them. The heat treatment of coal, oil and water necessitates dealing with the chemical reactions of solids, liquids and gases, and with all the laws, both physical and chemical, which govern these reactions. The finest equipment in the world, designed with utmost mechan-

ical precision, but without regard for the laws which govern the reactions carried out in it, is likely to be less useful than apparatus of the most wretched mechanical construction, but which does consider the chemical changes involved. Obviously the aim of any industrial operation is perfection both of process and apparatus.

Problems that are primarily chemical and which can be attacked most efficiently from a chemical point of view are common enough in gas manufacture. Who of the gas men present have not at some time or another faced the problems resulting from naphthalene, drip oil, fluctuating candle-power, deposited carbon, ammonia, sulphur, cyanogen, or any one of a dozen other factors. Further, every new development in gas manufacture will create new problems. Every improvement will involve some question or questions peculiar to it. The greater the number of researches, the greater is the progress in a given field, and the greater becomes the number of new problems.

Hitherto the greatest progress in American gas manufacture has been made along mechanical lines, and as Americans, we may be proud of this progress. Chemical development, however, has been far behind the mechanical and operating improvements. It may be said that we have been spending too much of our energy investigating the machine, rather than what is going on inside of the machine. Were the machine the end product of vital importance, improvements of this character would be unquestionable, but the gas factory of the future will earn, or fail to earn, its dividends as it turns out, or fails to turn out, the best relative yields of coke, gas, tar and ammonia. It is true that the machine and the process are vitally related; there may be objection to this point because engineers are constantly working to perfect processes. It seems in gas manufacture, however, that too many of the purely theoretical chemical problems have been left to the mechanical or erecting engineer for solution. A mechanical, electrical or civil engineer, whose primary profession is the



building and operation of machines and equipment, whose academic training consisted in the study of chemistry and physics during a part of two years, should not be expected to be as efficient in chemical research as the man who devoted himself exclusively to the study of chemical and physical phenomena; it is the latter, furthermore, whose primary profession to-day is the study of chemical and physical phenomena. To carry out high grade research and investigation in any line, well paid specialists must be employed. The able and efficient chemist and chemical engineer can do better things than analyze coal and iron oxide, however efficient he may be at the latter.

Gentlemen, the day is past when gas making is primarily a mechanical operation. Carbureted water gas constitutes approximately two-thirds of the gas made to-day, and it is no longer possible to buy a high grade paraffin gas oil for 3 cents a gallon. Consequently, the petroleum supply becomes a most vital and important problem to the American gas manufacturer to-day. The importance of the oil problem as related to gas manufacture can be conveyed by the fact that in 1913, Greater New York alone used approximately 3,860,000 barrels of oil in the manufacture of carbureted water gas.<sup>1</sup> During 1913, the same plants used approximately 1,600,000 tons of coal. On the basis of heat units involved oil has become as important in American gas manufacture as coal. Furthermore, Greater New York constitutes but one center for gas manufacture. I need not elaborate on the importance and seriousness of this oil problem, because you are fully acquainted with it. During the last decade, the increasing price of oil for gas manufacture has created what many gas men regard as a "dangerous" situation; and this is true despite the fact that never before in the history of the United States has so much oil been produced as to-day.

Why is it, then, that gas oil is expensive? Why should hundreds of millions of dollars worth of oil carbureting ma-

<sup>1</sup> Gas World, 1914, Vol. 61, p. 76.

chinery be threatened? What is it that makes the economical use of petroleum one of the chief problems of the gas manufacturer? It is, first, the scientific progress in petroleum refining, and, second, the changing character in composition of the oil from newly discovered fields. Through careful scientific investigation, and through the application of physical chemical principles, pure and simple, the refiner has perfected processes whereby the oil which you used to buy at 3 cents a gallon is now converted into gasoline and other end products which sell at several times that price. A representative example of this progress can be had from the testimony of Mr. Frank B. Lewis, Jr., Manager of the Standard Oil Company refinery at Whiting, Indiana, regarding the Burton process; this was offered at a recent court hearing in Chicago.<sup>2</sup>

"Q. Your Whiting plant is running exclusively on Mid-Continent oil, is it?

"A. Yes, sir.

"Q. Now tell us, Mr. Lewis, what percentage of the crude oil is refined into gasoline?

"A. With the present methods of distillation you can refine it all into gasoline if you wish to.

"Q. The entire percentage?

"A. You can take it all and convert it all into gasoline, except what coke is left in the still, and a little wax or petroleum tailings.

"Q. How long has that method been in use?

"A. About one year.

"Q. Is that method in use at the Whiting plant to-day?

"A. Yes, sir.

"Q. To what extent.

"A. To convert the fuel oil that we don't have any sale for, into lighter product; fuel and gas oil we don't have any sale for and contracts for, into

<sup>2</sup> The Petroleum Gazette, July, 1914, p. 5.

lighter products making them up into motor fuel, which is practically gasoline."

Furthermore, oil refiners all over the country are working on methods to convert every pound of gas oil into more valuable products. Facing facts, this means that if gas men are to continue the use of petroleum in carbureting water gas, they must resort to one of two alternatives:

- 1st: Greatly increase the yield of gaseous hydrocarbons from a given amount of oil, or
- 2nd: Perfect methods of using the millions of barrels of fuel oil which to-day are considered unfit for carbureting water gas.

One often hears the statement that these so-called fuel oils cannot be used in carbureting water gas. What right does any one have to make this statement? Is it the result of scientific study and investigation, or is it the result of experiments carried out under the same old conditions which prevail in the use of Pennsylvania, Ohio or Indiana petroleum?

Gentlemen, the purpose in emphasizing the gravity of the petroleum situation in connection with gas manufacture, is not to destroy hope nor to disseminate pessimism for the future. On the contrary, I believe that as soon as the gas manufacturer faces facts as they are, and seriously attacks the problem, increased efficiency and economy will result with petroleum still of primary importance as a raw material. Never in the history of the world has so much oil been produced as is being produced to-day. It is estimated that Oklahoma alone will mine 80,000,000 barrels.<sup>3</sup> California will contribute another 100,000,000 barrels.<sup>4</sup> Never in the history of the United States has so much oil been in storage as to-day. We are not facing an oil famine. We are facing a famine of knowledge concerning the chemical behavior of inferior petroleum which will facilitate their substitution for higher grade petroleum.

<sup>3</sup> Oildom, August, 1914, issue.

<sup>4</sup> Petroleum Review Vol. 30, pp. 599, 687, 717.  
Vol. 31, p. 3.

we accept the statement that the various so-called fuel cannot be used to carburet water gas, the necessity for specific chemical research becomes more acute than ever. Means that carbureted water gas is entering a rapid decline, and is to be replaced by coal gas, by-product coke oven gas, or other process gas not developed to-day. The problems involving physical chemistry will not be eliminated. The phenomena of chemical change are involved in any process wherein a solid or liquid is converted into a gas of different constitution.

The machine becomes of vital importance when it favors or offers optimum conditions for the end products desired. From operating costs, the relative merits of horizontal vs. vertical retorts depend entirely upon the influences of the retort's position on physical and chemical changes involved. The relative merits of any mechanical structure used in gas manufacture depend upon its influence on chemical reactions which produce the ultimate end products. The vertical retort completely filled, yields more tarless gas than the American practice of partially filling the retort, simply because the vapors are subjected to different physical conditions which influence the degree of cracking and tend to bring about equilibria concordant therewith.

This difference in end products, using the same type machine, indicates the complexity of the chemical reactions in gas manufacture and the close relations which exist between prevailing conditions and end products obtained. Both coke oven gas and retort gas are made by the application of heat to coal, yet the two gases vary considerably in their composition. Therefore, should we not look forward to a comprehensive understanding of the composition of the raw materials, such as coal and petroleum, and the changes and mechanism of the chemical changes that take place in them under different physical conditions?

When pointing out the seriousness and the dimensions of the gas man's chemical problems, and when referring to the

efforts and accomplishments of petroleum refiners, it would be unjust to overlook the excellent research work which has been started within the last three to five years. However, practically all of these investigations deal with coal. They are concerned with determining:

- 1st. The composition of the coal.
- 2nd. The initial decomposition products.
- 3rd. The final decomposition products under varying temperatures and pressures.
- 4th. The nature of the tars produced under varying temperatures and pressures.

I refer to the valuable work of Parr and Olin,<sup>5</sup> Burgess and Wheeler,<sup>6</sup> Ame and Pictet, Pictet and Bouvier,<sup>8</sup> Rau and Labris,<sup>9</sup> Vignon,<sup>10</sup> the Bureau of Mines, The United Gas Improvement Company, The Barrett Manufacturing Company, and numerous other investigators.

Much of this work may appear too academic and questionable from a practical point of view. On the other hand, our industry progresses as the result of just such investigations. Regardless of whether a low temperature process, for example, is valuable for direct application, the information obtained as to the constitution and chemical behavior of the coal, is of utmost importance. The same information with respect to petroleum is equally essential. As a matter of fact, prior to the works above referred to, the extent of change that takes place in the destructive distillation of coal was a question. In other words, do the end products occur in coal as such, or are they formed in the operation? Does benzene occur in coal as benzene, or is it formed in the distillation? To-day these questions appear unnecessary and out of place.

<sup>5</sup> Bulletin, University of Illinois Engr. Expt. Sta., 1912. Compt. rend., 1913, Vol. 137, p. 779.

<sup>6</sup> Trans. Chem. Soc., 1910, p. 1917; 1911, p. 649; 1914, p. 131.

<sup>8</sup> Compt. rend., 1913 (157) 779.

<sup>9</sup> Jour. f. gasb., 1913 (56) 533, 557, 589.

<sup>10</sup> Compt. rend., 1912, p. 1514.

now believe that benzene does not occur perceptibly in the natural coal, nor does it occur in appreciable quantities in East-Asian oils. The fact that it does occur considerably in both natural gas and coal gas tars of to-day, indicates conclusively that benzene is made in the course of the gas making process. There has been a transformation; a chemical change. That this change is not a simple one, can be observed from the indications referred to. Further, it is found that when coal is distilled under a vacuum, very little benzene is formed. Hence the mechanism of benzene formation is fully understood, and it will be a relatively simple matter to increase or decrease the yield. Benzene is referred to purely as an illustration. The same reasoning applies to all tar, ammonia and hydrogen formation in connection with gas manufacture. If naphthalene is an undesirable product in gas manufacture, its absence is not conclusive proof that its production cannot be avoided.

The variation in the tar obtained from different processes of coal, oil and coke oven gases, is entirely due to variations in the prevailing physical conditions. It is a fact that these conditions differ, yet the initial materials used in the process of manufacture may be the same. With the reason for these differences fully understood; the optimum conditions for the manufacture of both tar and gas will be understood and better realized. The tars which result from the destructive distillation of coal or oil, under different physical conditions, vary widely as do the physical conditions under which they are made. In the course of a research carried out by Prof. M. C. Baker and the writer,<sup>11</sup> on the destructive distillation of petroleum, it was found that the tar made under greatly increased pressure was radically different from that obtained by cracking the same oil under atmospheric or increased pressure. The vacuum tar was of much lighter specific gravity; contained practically no free carbon; no naphthalene or benzene settled out of the heavier distillates of the tar; the

*Journal of Ind. & Eng. Chem.*, 1914, pp. 383, 472.

tar combined readily with 1.82 sp. gr. sulphuric acid. Tars resulting from cracking the same oil under increased pressure contained much free carbon; they were of considerably higher specific gravity; naphthalene and anthracene settled out of the distillates; they contained benzene; they would not combine readily with 1.82 sp. gr. sulphuric acid. The gas made under the two conditions was of equally different composition. The vacuum gas was a "dry" gas, in that it contained practically no benzene; on the other hand, it was high in ethylene homologues. The volume of uncombined hydrogen obtained under vacuum conditions was very much less than when the machine was under increased pressure. Further, there was practically no deposit of free carbon when working under a vacuum, whereas when the pressure on the machine was increased to three atmospheres, over 50 per cent., by weight, of the original oil was deposited as carbon.

Let us see how far the variables common to any gaseous chemical reaction have been investigated with respect to illuminating and heating gas. They are five in number:

1. Temperature.
2. Pressure.
3. Concentration (Mass action).
4. Duration (Time).
5. Contact Surface.

On the basis of combinations and permutations, it becomes evident that a great variety of manufacturing conditions can be obtained. Opinions naturally differ as to when a field has been properly and sufficiently investigated, and I, therefore, do not pretend to determine what proportion of the work remains to be done. It remains for each individual to form his own opinion. The field of temperature has been widely investigated, but principally with the machine under atmospheric pressure. Experiment shows that the moment we change the pressure, new results are obtained and a new series of experiments suggested. Certain it is that much remains to be done in the field of concentration, pressure and contact

surface changes. The application of various conditions for different periods of time still offers field for investigation.

I repeat that even if such investigations do not result in radically new processes, they will yield valuable information for a better understanding of, and improvement in, present day processes. From a practical viewpoint, we may not as yet be able to see the advantages to be gained from the application of such scientific investigations, and on the contrary, we may see disadvantages. However, this should not prevent our exploring the field. Industrial experience has again and again proven that the theory of to-day is the practice of to-morrow. In the absence of theoretical considerations, applied chemistry to-day would be in the mediaeval stages. As a typical example, the investigations of Haber concerning the manufacture of ammonia from hydrogen and nitrogen were on a purely theoretical basis.<sup>12</sup> From an initial yield less than one-fourth of 1 per cent., the process has been perfected to give a yield of well over 10 per cent of ammonia. From the idea of a man whose principal tools were theoretical chemistry, mathematics and physics, laboratory experiments developed into a process of commercial importance. The same laws maintain in the ammonia production of the gas plant that maintain in Haber's experimental and industrial apparatus.

The combination of nitrogen and carbon in the formation of cyanogen compounds is influenced by varying physical and chemical conditions just as surely as is the production of ammonia, whether from coal distillation or directly from the elements as in the Haber process.

The application of physical chemistry to industrial problems in mathematical terms furnishes a means for quantitatively expressing yields and reactions taking place. I refer to the equilibrium relationship. Under some conditions, it is highly important that the system reaches a state of chemical equilibrium; under another condition, it would be fatal for the

<sup>12</sup> *Zeitsch. f. Elek.*, 1913, p. 53.



system to reach such equilibrium. Let us consider a few typical examples:

No.	Reactions	Heats of reaction	Volume changes
1	$C + 2H_2 = CH_4$	+18900	2 to 1
2	$2C + H_2 = C_2H_2$	-58100	1 to 1
3	$3C_2H_2 = C_6H_6$	+163000	3 to 1
4	$C + H_2O = CO + H_2$	-29300	1 to 2
5	$CH_4 + H_2O = CO + 3H_2$	-48200	2 to 4
6	$CO_2 + C = 2CO$	-39650	1 to 2

No.	Partial pressures	Approximate	
		$K_{900}$	$K_{600}$
1	$K = \frac{CH_4}{(H_2)^2}$	0.077	0.003
2	$K = \frac{C_2H_2}{H_2}$	$1.1 \times 10^{-13}$	$5.7 \times 10^{-10}$
3	$K = \frac{C_6H_6}{(C_2H_2)^3}$	$9 \times 10^{28}$	$1.2 \times 10^{18}$
4	$K = \frac{CO \times H_2}{H_2O}$	0.2	25.0
5	$K = \frac{CO \times (H_2)^3}{CH_4 \times H_2O}$	0.06	346.0
6	$K = \frac{(CO)^2}{CO_2}$	0.1	59.0

It becomes evident that for some reactions, an elevation in temperature favors the preservation and formation of hydrocarbons, whereas for other reactions, the same temperature is destructive. Considering equations (4) and (5), two of the most vital in present carbureted water gas manufacture, one finds that a temperature of 900 C is favorable to the CO and H<sub>2</sub> formation of both (4) and (5), but it is unfavorable to methane preservation of (5). On the other hand, a temperature of 600 C is unfavorable to the formation and preservation of CO and H<sub>2</sub>, but is decidedly more favorable than 900 to hydrocarbon preservation of (5). At this lower temperature, however, the CO<sub>2</sub> of (6) predominates. From reaction (1), it becomes evident that methane is destroyed by high temperatures.

Numerical equilibrium expressions permit of quantitatively indicating the influence of three of the most important vari-

ables of a gaseous reaction, *i. e.*, temperature, pressure and concentration. The value of the equilibrium constant increases or decreases with the temperature. Although pressure and concentration variations do not change the value of the equilibrium constant for a given temperature, the use of such equilibrium expressions enables one to calculate the influence of changes in pressure or concentration for any given temperature. In reactions (1) and (3), referred to above, there is a decrease in the number of volumes due to the reaction; in reaction (4), (5) and (6) there is an increase in the number of volumes due to the reaction; in reaction (2) there is no change in the reacting volumes. According to the principle of LeChatelier, pressure stimulates those reactions involving contraction, and vacuum stimulates those reactions involving expansion. Pressure and vacuum are without influence on those reactions involving neither contraction nor expansion. For detailed consideration of the application of numerical equilibrium relationships, see articles by Whitaker and Rittman,<sup>13</sup> and Rittman.<sup>14</sup> By a correlation of equilibrium conditions for the various reactions involved in gas manufacture, much help can be had in determining the course of experiments. Unfortunately, equilibrium relationships as shown, do not indicate the speed of the reaction involved; they indicate the state of affairs after complete reaction has taken place and the system is balanced. Therefore, the information indicated by an equilibrium relationship is not complete in itself. No single reaction can be considered exclusively by itself. All the reactions in a process are vitally interrelated, though any single reaction, or set of reactions, may be extremely important as indicating a tendency.

The shape of the machine cannot change the equilibrium constant for any given reaction. It is easily possible to reach the same equilibrium in entirely different types of machines. The machine is vitally important insofar as its design pro-

<sup>13</sup> Jour. Ind. & Eng. Chem., 1914, pp. 383, 472.

<sup>14</sup> Journal of the Soc. of Chem. Ind., 1914, p. 626.

Metallurgical & Chemical Engineering, 1914, p. 475.

vides conditions for a favorable or unfavorable equilibrium; or insofar as its design hastens or retards the system in reaching equilibrium. It would be an easy matter to expand indefinitely on the importance and practical application of equilibrium relationships with respect to gas manufacture, but it seems advisable to await further experimental evidence.

In conclusion, I would say that the application of physical chemistry to gas manufacture is stimulating, because gas manufacture is a chemical and chemical engineering problem. It involves solids, liquids and gases with all the chemical and physical laws governing these three states of matter. The questions of energy and heat transformations determine profit or loss. Nowhere is the question of chemical equilibrium more important. Vapor pressure, surface tension, solubility, diffusion, dissociation, polymerization, catalysis, decomposition, specific heat, latent heats of reaction, speed of reaction constitute fundamentals in physical chemistry, and are all vital to the gas man. The five variables,—temperature, pressure, concentration, duration, and contact surface, offer a flexibility which should permit equal flexibility in the character of the end products obtained. Complicated problems become elementary in the light of physical chemistry. The pendulum swings to the extreme where gas manufacture becomes primarily a problem involving theoretical and applied chemistry. Without its application the industry cannot develop. However, in view of the work which has recently been done and which is being done, we can feel that gas manufacture as a chemical problem is gradually coming into its own.

THE ACTING CHAIRMAN: I, for one of the chemical engineers of the country, feel as I have received a well-merited spanking. We need just such talks to push us along to where we should go without the spanking. Such a paper has not been presented any too soon. As Mr. Rittman has said, investigation into oil has been carried on only during the last five years. There are many other things which each of us can think of

present problems we should consider. We do not need  
told "where to get off," but where to get on.

pe this paper will have free discussion.

F. A. H. WHITE (Ann Arbor, Mich.): (Written discus-  
communicated.) The people of this country are to be con-  
tated on the energetic and broad-minded policy of their  
a of Mines which is constantly striving to promote more  
t utilization of our mineral resources. The utilization of  
d gas was one of the earliest subjects to receive attention  
the Bureau, and already a number of bulletins of value  
gas industry have been published. Mr. Rittman's paper  
ery proper emphasis on the chemical nature of all the  
ses involved in gas manufacture. Their control can only  
through careful chemical study. This field of research  
emely difficult because of the number of reactions which  
simultaneously and the fact that few of them are carried  
ilibrium in the manufacturing process. Especial care  
be exercised in transferring results from the laboratory  
manufacturing scale in such cases, because every change  
e allowed for reaction and every change in the nature of  
ntact surface, influences the result to an extent which at  
seems wholly out of proportion to the apparent magni-  
f the change. The usual purpose of a technical investi-  
is to obtain a specific improvement or to remedy a  
c evil. Unfortunately, the study must usually be  
d when the immediate ends are fulfilled or if the work  
ot promise results of tangible value. Some of the larger  
ations can afford to make a thorough study of a problem  
f it is not apparent that the results will be distinctly  
rian; and it is clearly a function of a government re-  
laboratory to exhaustively study those reactions of  
mental importance whose solution requires the uninter-  
attention of trained investigators for long periods of  
Mr. Rittman is entirely right in emphasizing the need  
areful study of fundamental reactions. Gas manufac-

ture is a branch of chemical engineering and needs every aid which chemistry and engineering can give it.

THE ACTING CHAIRMAN: We would like to hear from someone else on this matter.

MR. V. VON STARZENSKI (Schenectady, N. Y.): I think we have every reason for being grateful to the Bureau of Mines for the three papers which have been presented this afternoon, and I move that we send a special vote of thanks of this Section to the Director of Bureau of Mines for the privilege of listening to Mr. Burrell, Dr. Porter and Mr. Rittman this afternoon.

(Motion seconded and carried.)

THE ACTING CHAIRMAN: Mr. Rittman said if he had more time, he would tell us something about equilibrium constants. Now we have time, and we should like to hear something on equilibrium constants, if Mr. Rittman will tell us something.

MR. RITTMAN: Gentlemen, it is a rather complicated thing. We all know that if carbon is heated in the presence of air, under one condition we will get a certain percentage of carbon dioxide, and under other conditions of temperature, we will get another percentage of carbon dioxide. Likewise, each temperature will yield a definite percentage of carbon monoxide. There is equilibrium between carbon dioxide and carbon monoxide for each temperature. Carbon dioxide plus carbon is reversible with two molecules of monoxide. The reaction is usually written with arrows ( $\rightleftharpoons$ ) instead of the conventional equality mark ( $=$ ) to bring out the fact that the reaction can proceed in either direction; its direction is determined by physical conditions such as temperature, pressure, concentration, contact surface and duration. When the reaction in one direction is exactly equal to the reaction in the opposite direction, then the system is in equilibrium; *i. e.*, the relative percentages of carbon dioxide and carbon monoxide do not change.

Take for instance a gas producer (making diagram). Now, then, if your temperature is low, this reaction (indicating two

molecules of carbon monoxide) takes place only to a moderate degree. If your temperature is high, all of the carbon dioxide goes to carbon monoxide. There is a relation between the two which is expressed by



I will write this  $2\text{CO}$  equal to  $\text{CO}$  plus  $\text{CO}$ , and equilibrium exists when this  $\text{CO}$  times  $\text{CO}$  (or  $\text{CO}$  squared) divided by the  $\text{CO}_2$ , has a definite numerical value

$$K (\text{equilibrium constant}) = \frac{\text{CO} \times \text{CO}}{\text{CO}_2} = \frac{(\text{CO})^2}{\text{CO}_2}$$

$K$  represents an equilibrium constant. For each temperature, it has a definite numerical value. Let us substitute some numerical value. Let us say that its value is 0.5. Practically this can be experimentally determined; also with the aid of thermodynamics, it can be calculated.

Now then,  $\text{CO}$  plus  $\text{CO}$ , I will write as  $(\text{CO})^2$ . Suppose I have a partial pressure here of 0.5, in other words 0.5 represents the total pressure of  $\text{CO}$ , then  $(\text{CO})^2$  equals 0.25. Substituting, we have

$$K = \frac{(\text{CO})^2}{\text{CO}_2} \quad 0.5 = \frac{0.5 \times 0.5}{\text{CO}_2} \quad \text{CO}_2 = \frac{0.5 \times 0.5}{0.5} = 0.5.$$

In other words, when the equilibrium constant for the indicated reaction equals 0.5 and the partial pressure of  $\text{CO}$  is one-half atmosphere, then the partial pressure of  $\text{CO}_2$  must also equal one-half atmosphere in order to maintain equilibrium.

Equilibrium conditions can be calculated for a reaction before you touch a beaker or a hammer. Say we are burning coal in a boiler, the old idea was to convert 100 per cent. of it into carbon dioxide. Equilibrium conditions indicate that it cannot be done, and at the same time maintain a high temperature.

Supposing you eliminate any excess of oxygen, equilibrium relationships, purely aside from practical experience, indicate that you are in trouble. That explains why from a practical side it is advisable to have a little oxygen in your flue gas, also

why it is practically impossible to get all carbon dioxide with the complete exclusion of carbon monoxide.

The point is that no chemical reaction goes completely in one direction under all conditions. Every reaction is influenced by a reaction proceeding in the opposite direction. When the rate of change in one direction is exactly counterbalanced by the rate of change in the opposite direction, the system is in a state of equilibrium and the number which expresses this relationship is known as the equilibrium constant. If any of you care to follow up this matter in relation to its practical application, I would suggest that you read the references cited in my paper just read.

THE ACTING CHAIRMAN: I think we feel greatly indebted to Mr. Rittman for his graphic description.

MR. W. S. BLAUVELT (Detroit): Mr. Chairman, we passed a formal vote of thanks to the Director of the Bureau of Mines. I think we should equally express our appreciation to the gentlemen who have so kindly come forward with these papers.

Mr. von Starzenski's motion called for a vote of thanks to the Director of the Bureau of Mines. I think there should be a separate and distinct vote of thanks to the gentlemen representing the Bureau of Mines who have just made this afternoon's session so instructive and interesting to the Chemical Section. I make that motion.

(Motion seconded and carried unanimously.)

#### REPORT OF THE SECTIONAL NOMINATING COMMITTEE.

THE ACTING CHAIRMAN: The Nominating Committee will now report.

MR. W. H. HINMAN (New York): The Committee on Nominations takes pleasure in presenting the following names: Mr. W. S. Blauvelt (Detroit), Dr. A. H. Elliott (Flushing, N. Y.) and Donald McDonald (Albany).

MR. E. C. UHLIG (Brooklyn): I move that the report of

Committee be accepted and adopted, as the three designees of the Chemical Section to the Nominating Committee of the Association for election next year as vice-president of the Chemical Section.

Motion seconded and carried.)

ACTING CHAIRMAN: We will now call on Chairman Rittman to close the meeting.

CHAIRMAN: Gentlemen, I have nothing further to say except to thank you for the interest you have taken. I have been more than pleased—I have been surprised—at the number of members present at the Chemical Section, and this initial meeting gives promise of real results to the industry from starting this section, and that there is some hope of the chemist coming to his own in the gas industry. When we reach the point where we can tell the difference between a “billy-goat and an equilibrium constant,” to quote Mr. Rittman, we, in turn, may be able to do more for the advancement of the gas industry.

I have been given some papers this afternoon that will be stimulating to everyone of us. It is a wonderful thing for us to find how large is the realm in which our ignorance is supreme. We have seen a little of that realm this afternoon.

Are there anything else to come before the section?

VICTOR VON STARZENSKI (Schenectady, N. Y.): Is there any time you want to kill, Mr. Chairman?

CHAIRMAN: There is no reason to remain in session unless you have something special to bring up.

VON STARZENSKI: Last winter the Chairman asked me to read a paper on the liquid purification of gas. I agreed to do this assuming that our coal gas plant would be completed by schedule time, which was May 1, 1914. Due to the vicissitudes of construction work, we did not start up until August, and I am, therefore, unable to present any data worthy of publication, but I would like to present a few ideas and start a



little discussion as there seems to be such a lack of information on the subject of removal of hydrogen sulphide by ammonia.

As you all know, liquid purification of hydrogen sulphide is accomplished by removing the hydrogen sulphide by so-called caustic ammonia. This caustic ammonia is obtained by heating weak ammoniacal liquor of 1 to 2 per cent. strength, up to 190° F. or 215° F. and driving off the hydrogen sulphide and carbon dioxide. Exactly what that temperature is, is indefinite.

Last year Mr. J. J. O'Neill, presented a paper in which he said that 1 per cent. ammonia liquor would not be changed in ammonia strength, but would have the hydrogen sulphide and carbon dioxide changed if it were heated up to 214° F. We experimented and found that while the hydrogen sulphide and carbon dioxide were removed, the ammonia liquor was also weakened. It takes such a large quantity of that weak liquor to remove the hydrogen sulphide in the gas, that you cannot build up the strength of your caustic ammonia, as it is necessary to return such large quantities of weak liquor to the still from the scrubber.

We have done a little more experimenting during the past week, and we find by increasing the rate of flow of the weak liquor 50 per cent. through the heater, that the strength of the ammonia is not affected as much as at the lower rate. We originally started by heating the liquor up to 212° F., but found that under the low rate, that 1.25 per cent. liquor was reduced to 0.8 per cent., while it seems that under the increased rate of flow through the heater, that same strength liquor is only reduced to 1.1 per cent. The increased rate, therefore, looks to be a step in the right direction.

By that way, we drive off 80 per cent. of the hydrogen sulphide and 45 per cent. of the carbon dioxide. By passing 5.5 gallons of this liquor per thousand feet of gas through the first half of our ammonia scrubber, we are able to remove from 35 to 40 per cent. of the total hydrogen sulphide in the gas.

we can increase the amount of the liquor which goes  
 a, I do not see why we cannot get an absorption of 80  
 per cent.

CHAIRMAN: I am sure we are interested in this  
 ent of Mr. von Starzenski. I am glad we got a word  
 , as we had hoped to have a paper presented on that

A. H. ELLIOTT (Flushing, N. Y.): A good many  
 go I tracked up this same path, and I did it in exactly  
 ne way. I found if you took ammonia liquor and  
 caustic lime, that is to say, milk of lime, sufficient to  
 with the carbon dioxide and the sulphur, you could get  
 r that would purify gas. Now, I did not go far enough  
 to get results. I was called away from the job and  
 n an unfinished condition.

certain number of grains of calcium hydroxide will dis-  
 a water. You might take out your sulphur and carbon  
 without trouble, and then have a liquor you could  
 hat is only a suggestion.

CHAIRMAN: Is there anyone else with anything they  
 like to bring before the Institute as a message from  
 emical Section?

VON STARZENSKI: I have noticed that papers are pre-  
 and numerous questions are asked and some answered.  
 s to me the proper way to do that is to answer each  
 n when it is asked.

CHAIRMAN: I think that suggestion of Mr. von Star-  
 s a very good one; the only difficulty is the time limit.

WAY: I move that we adjourn.

ELLIOTT: Before that motion is put, Mr. Chairman, I  
 o express my gratification at the fact that this section  
 d such an able chairman to conduct our Proceedings  
 ke things go so smoothly. I think we should express  
 ppreciation in the form of a vote of thanks of this  
 I make a motion to that effect.

(Motion stated by Mr. C. W. Hinman and carried after being seconded.)

(Motion to adjourn seconded and carried.)

**THE CHAIRMAN:** The Chemical Section stands adjourned  
Adjourned, 5 :00 P. M.

## MANUFACTURING SECTION.

Afternoon Session, Wednesday, October 21.

CAPT. W. E. MCKAY (Boston), *Chairman*, Presiding.

MR. W. VAN ALAN CLARK (Astoria, Long Island, N. Y.),  
*Section Secretary*.

The Chairman called the meeting to order at 2:18 P. M.

THE CHAIRMAN: The first business on the afternoon program is the Report of the Committee on Refractory Materials, by Mr. H. Russell, Chairman, of Rochester, N. Y.

### REPORT OF THE COMMITTEE ON REFRACTORY MATERIALS.

By way of introduction to this, the first report of the Refractory Materials Committee, it will not be amiss to state briefly the scope of the work of this committee.

In its broadest aspect, this should be to place before the gas engineer, builder and fire brick manufacturer, information which will enable them to select and produce that refractory material which will prove most efficient for the required work.

In order to accomplish this, it is necessary to know, first, the conditions which the refractory material must meet in practice, second, the qualities the material must possess in order to best meet these conditions, and third, we must have satisfactory methods of testing refractory materials for these qualities. Such information will result in more intelligent use of refractory material by gas engineers and an improved product by fire brick manufacturers.

It is quite evident that satisfactory progress in the study of these problems demands the sincere co-operation of three parties—the maker, the builder and the user. The last two are well represented on your Committee. The securing of the co-operation of the maker has been taken care of through the agency of the Committee on Gas Refractories of the Refractories Manufacturers Association, most of whose committee members are also members of the Institute. The work which has been accomplished is a result of the joint action of the

two committees, and all the meetings to date have been joint sessions. These meetings have been productive of a spirit of fairness, co-operation, and open-mindedness on the part of all, that has been most gratifying. It is perhaps not out of place to say here that the appointment of your Committee and the starting of this study was in a great measure due to the suggestion of the manufacturers of refractory material.

It was also found that a great deal of work had been done by the Bureau of Standards, and that the Bureau on Refractory Materials should be of great assistance to the work of the committees, and Mr. A. V. Bleininger, Ceramic Chemist of the Bureau of Standards, kindly consented to act as a member of the Committee, with the approval of the Bureau. Mr. Bleininger is also Chairman of Committee "C-8" on Refractory Materials, of the American Society of Testing Materials.

The work of the Committee to date has been fairly well outlined in the reports of meetings, which have appeared in the *Institute News*.

At the suggestion of your President, a very complete abstract bibliography of the subject of Refractory Materials has been prepared by Messrs. F. N. Morton and W. E. Saunders under the direction of Mr. W. H. Fulweiler. This has been carefully indexed by Mr. D. S. Knauss. All these gentlemen are members of The United Gas Improvement Company staff, and the Institute is greatly indebted to them for this very valuable work. This bibliography is submitted with this report and your Committee recommends that it be printed by the Institute, in a size and form suitable for library reference, and sold to those desiring copies. Inasmuch as the American Society for Testing Materials had appointed a Committee "C-8" on Refractory Materials, whose duty it is to prepare standard methods of test for such materials, your Committee decided to conduct this part of its investigations in co-operation with this Committee. Committee "C-8" has appointed sub-committees on, and will prepare standard methods covering, the following properties of refractory material:

Fusion points.  
 Chemical and mineralogical analyses.  
 Thermal conductivity and expansion.  
 Porosity and permanent volume changes.  
 Load tests.  
 Crushing, abrasion and other physical tests.  
 Slugging action.

Our Committee is now securing data to forward to these sub-committees, so that they will be able to give us soon, tentative methods of tests of gas industry refractory material. By means of circular and individual letters sent to representative gas engineers and gas works builders, the Committee tried to ascertain the temperature and loading conditions to which refractory material is being subjected at present time in various types of carbonizing plants. The results show that in modern carbonizing plants we may expect normal operating temperatures as follows:

PLACE AND TEMPERATURE, DEGREES F.

	Combustion chamber	Interior carbonizing chamber	First pass waste gas flue	Second pass waste gas flue
Temperature, 400	1,600-2,700	1,500-2,400	1,300-2,200	570-1,600

The maximum temperature to be expected under abnormal conditions is given by several observers as 3,000° F. The maximum load in the settings varies with the different types of plants at from 12 to 28 lbs. per square inch, and the temperatures at these points of maximum load vary from 2,000° F. to 3,000° F. As to the question whether they would operate in settings at higher temperatures provided the material could safely stand such temperatures, opinion was about equally divided. This information has been tabulated and will be used in the preparation of standard methods of test, and will be of material help to the Committee in its future studies.

The Committee desires to report progress on the matter of preparation of standard specifications for fire clay and refractory material for gas works use. Practically all the time of the last three meetings of the Committee has been devoted to

the discussion of these specifications. Your Committee finds that it will be necessary to conduct rather elaborate experiments in order to determine the behavior of silica and clay materials under load at high temperatures. These experiments have been arranged for, and will be conducted at the testing laboratory of the Bureau of Standards in Pittsburgh, under the direction of Prof. A. V. Bleining. We believe that the result of those experiments will enable us to specify refractory qualities of material that will be satisfactory both to the users and manufacturers.

We have corresponded with representative technical schools and universities, as well as the Bureau of Standards, and all have assured the Committee of their co-operation in the carrying out of tests.

We have arranged, through Mr. F. J. Bywater, Secretary of the Refractory Committee of the English Institution of Gas Engineers, for an interchange of information. The results of their investigations have been a material help to your Committee, and we in return have been able to reciprocate, especially in the matter of silica material.

Your Committee feels that it has made only a start in the work which is to be done, and believes that the Refractory Materials Committee should be a permanent one. The work this coming year will consist in the completion of the standard specifications, the preparation of standard methods of test, and an investigation of the properties of refractory material together with a study of operating conditions, in order to determine the qualities a fire brick material should possess to fit it for a given gas works use.

HERMAN RUSSELL, *Chairman*,

J. W. BATTEN,	J. P. KENNEDY,
W. H. BLAUVELT,	C. J. RAMSBURG,
J. S. DEHART,	J. H. TAUSSIG,
W. H. FULWEILER,	H. L. UNDERHILL.

MR. R. NORRIS (Philadelphia): Preliminary to discussion,

the acceptance of the report, the adoption of its recommendations, and that the work of the Committee be continued the coming year.

ral members seconded the motion.

CHAIRMAN: Is there any discussion?

There being no discussion on the motion, the question was carried.

The next paper is "Oil Tar Separation, Recovery and Disposal" by Mr. R. E. Wyant, of New Haven, Conn.

# OIL TAR SEPARATION, RECOVERY AND DISPOSAL.

## SEPARATION.

Considering this subject, it is not the writer's purpose to enter into a discussion of the separation of tar from water first, because he has no method to suggest which is not already well known, and second, because the usual pieces of apparatus—scrubbers, condensers, P. & A. extractors, shaving scrubbers, and purifiers—have been thoroughly tested as to efficiency as tar separators by long and general use. Results of very carefully conducted tests of all of this apparatus has been made by Dr. A. P. Beardsley, of New Haven, Connecticut, and the results were presented by him in a paper before the New England Association of Gas Engineers, at the 1912 meeting at Boston. These results were obtained under average working conditions, and I believe in what may be fairly expected of such apparatus.

The tests show a production of tar equal to 14.2 per cent. of volume of oil used. A summary of the results is given below showing the performance in removing tar of the various pieces of apparatus in sequence.

Apparatus	Per cent. tar removed	Per cent. efficiency	Per cent. equivalent of oil
Scrubbers . . . . .	21.3	21.3	3.02
Condensers . . . . .	62.5	79.4	8.87
P. & A. . . . .	12.96	80.0	1.84
Shaving scrubbers . .	2.86	88.20	0.41
Purifiers . . . . .	0.37	98.00	0.05
Escape purifier . . . .	0.01	—	0.01
	100.00		4.20



It is undoubtedly true that tests may be found showing better efficiencies than above indicated for the various pieces of apparatus. It must be borne in mind, however, that it is not always possible to maintain, in actual operation, the maximum efficiencies possible for any piece of apparatus. We must make gas as needed, and varying conditions, and quantities of gas passing the apparatus, seriously affect the efficiency.

There is much diversity of opinion among gas engineers as to the relative value of some of the apparatus mentioned. It is sometimes maintained that the P. & A. extractors are alone sufficient for the removal of the tar fog remaining in the gas after condensation. On the other hand, shavings scrubbers are considered quite indispensable by a large number of engineers. In any case, both are introduced where the tar contained in the gas is highly attenuated, and difficult to remove, and both, at best, can remove but a moderate proportion of the total tar. The tests show that both pieces of apparatus are highly efficient in removing the tar that comes to them, and that the addition of the shavings scrubbers relieves the purifying material of about 140 pounds of tar for each million cubic feet of gas passed. The shavings scrubbers also fulfill an important office in saving the purifying material during such variations of pressure as impair the efficiency of the P. & A. extractors.

All of the above remarks apply to tar in the form of liquid or fog, and it will be observed that a measurable quantity of tar per million feet of gas is carried past even the purifiers in this form. In order to conserve the illuminants in the gas, the various scrubbing operations must be carried on at a temperature near 100° F., and for this reason, we cannot hope to remove all of such tar vapors as have an appreciable vapor tension at this temperature. It is, of course, the subsequent cooling after purification, that accounts, in a measure, for the condensate found in holders and drips.

#### RECOVERY.

Depending upon its disposal, the recovery of the tar after

tion from the gas, may or may not present difficulties. If there is a small proportion of emulsion of tar and water usually formed in the condensation and separation of tar from the gas. If the whole of the tar separated in the scrubbing devices be passed through gravity separator and collected for prompt disposal, the emulsion passes with the water-free tar and forms a mixture of low water content. If, on the other hand, the tar is allowed to accumulate for long periods, as, for instance, in a holder tank, it is found that a further separation takes place between the water and the emulsion, leaving a low water content and the emulsion. The writer has passed through the latter experience. Oil tar has been stored for several years in a holder tank and reclaimed by skimming, as required, from the bottom of the tank. This arrangement was perfectly satisfactory until it was discovered that the tar drawn from the holder suddenly contained large quantities of water. Investigation revealed the fact that the apparently large stock of oil tar consisted of an emulsion of tar with water.

To determine the quantity of tar present, samples were drawn from the holder tank at definite varying elevations, and the samples analyzed by distillation. The analyses showed a water content of from 2 per cent. to 3 per cent. for the first 18 in. from the bottom of the tank. Samples taken from the bottom showed the presence of 46 per cent. of water and this percentage increased rapidly to 80 per cent. at 4½ ft. and 90 per cent. at 12 ft. from the bottom. A sample containing 6 per cent. water (by volume) gave the following characteristics for the water-free tar.

. Specific gravity 1.070 at 60° F.		
. Viscosity (Engler) 77° F.		
50 cc. in. 22''		Specific viscosity 1.95
100 cc. in. 47''		2.05
200 cc. in. 1'-45''		2.08
. Flash point 119° F.		
. Fire point 154° F.		
. Free carbon by CS <sub>2</sub> extraction 0.41 %		

A sample containing 66 per cent. water by volume gave for the water-free tar the following:

1. Specific gravity	1.043 at 60° F.	
2. Viscosity (Engler)	77° F.	Specific viscosity
50 cc. in. 20''		1.77
100 cc. in. 42''		1.83
200 cc. in. 1'-32''		1.82
3. Flash point	120° F.	
4. Fire point	133° F.	
5. Free carbon by CS <sub>2</sub> extraction		2.17%

It will be noted that the sample containing the large percentage of water has a lower gravity, is slightly more fluid and more volatile, while the percentage of free carbon is increased about 2 per cent.

This emulsion, even containing 90 per cent. of water, is very deceptive in appearance, as it looks like good tar. It is extremely persistent, and could not be broken in the laboratory by filtration through either paper or cloth, nor by grinding in a paint mill. Centrifugal separators were entirely ineffective, and prolonged heating was found useless. Separation was also attempted by steam jets in contact with the emulsion. It was finally felt that success was likely to be obtained only through a distillation process and this method has been carried out in a simple and fairly effective manner by use of existing apparatus.

The water gas apparatus is equipped with the usual scrubbers filled with wooden grids following the wash box or seal. Usually water is caused to circulate through these scrubbers and descends against the upward flow of the gas. Tar is separated from the hot gas and passes out at the bottom of the scrubbers with the circulating water into gravity separators. Here most of the tar is caught, and the water passes on through the separators into a collecting tank from which it is again pumped to the top of the scrubbers. As the circulating water is raised nearly to the boiling point by its contact with the hot gas, it is necessary to place the circulating pumps below the collecting tank, so that the hot water will flow to the

With this apparatus at our disposal, the tar emulsion substituted for the circulating water and the gravity separator, by-passed, so that the tar removed from the gas, with the emulsion directly to the collecting tank. As emulsion is broken, by the evaporation of its water, the tar settles to the bottom of the tank, and it is necessary only to pump out the tar each day and replace it with emulsion. By this method, we are able to treat about 1,000 gallons of emulsion per million feet of gas made.

Regarding the formation of this extremely watery and permeable emulsion, the writer has no positive knowledge. Its formation is thought to be based primarily upon the presence of free carbon or dust mixed with the tar. It is quite evident, however, that the quantity of water carried by the emulsion is independent of the quantity of free carbon present in the sample before mentioned, which contained 66 per cent. of free carbon. It will be recalled that the water-free tar was found to contain only 2.17 per cent. of free carbon. Vertical retort tar containing from 6 per cent. to 8 per cent. is but slightly emulsified during condensation, although a 50 per cent. mixture of this tar with water can be permanently emulsified by mechanical action. Horizontal retort tar containing from 25 per cent. to 30 per cent. free carbon, does not approach, in the emulsion formed, in condensation, the water content found in the oil tar. It would seem, therefore, that the peculiar oil tar emulsion is due rather to the treatment of the tar during condensation and perhaps to its lighter and more limpid character than to the amount of free carbon contained. From the fact that the emulsion is found at the outlet of the first scrubber, it is evidently formed either in the seal or in the scrubber, or both. This fact suggests a mechanical formation due to violent agitation of the newly condensed tar in the water seal box.

#### DISPOSAL.

For many years, the disposal of oil tar has been a serious problem to many gas companies, and for that reason, the tar



has been largely used for fuel. While excellent for this purpose on account of its high calorific power and ease in handling, it should be worth more than its fuel value.

As a boiler fuel, it can be burned successfully either in combination with a coal fire, or in a suitable setting alone. The latter case is by far the more efficient if boiler equipment and tar supply admit of the isolation of one or more boilers for its exclusive use. Its high calorific value and its ease in storing and handling give low evaporative cost.

Recently a much wider field of usefulness has been opened to oil tar in the demand for road material. For such purposes, however, the tar should be treated by distillation.

As a dust laying material, it has been used to some extent in the crude state, but many objections have developed in this practice. Among them may be mentioned its odor, danger of ignition owing to low flash point, its liability of containing large amounts of water, and the frequent applications necessary to preserve its effectiveness. All of these objections can be readily removed by distillation either in a fire or steam still. The steam still involves a much smaller expenditure for apparatus, and is effective and rapid. For effective distillation by steam, however, it is desirable to blow live steam directly into the tar after the temperature of the tar in the still has been raised above 212° F. The distillation should be continued until the specific gravity has been raised to about 1.10 at 60° F., and the flash point to about 145° F. Such tar should show by the distillation method of the U. S. Office of Public Roads, characteristics about as follows:

	Degrees C.	Degrees F.	By weight Per cent.	By volume Per cent.
1.	To 110	230	0.0	0.0
2.	110 to 170	230 to 338	1.0	1.4
3.	170 to 270	338 to 518	37.0	40.6
4.	Residue	—	62.0	58.0

As compared with petroleum road oil, the oil tar described, is much more penetrating, and, therefore, is more readily absorbed by the dust, and the larger pitch residue builds a more permanent surface.

road surfacing, the distillation should be carried out, thus reducing the penetrating capacity and increasing the proportion and stickiness of the pitch residue.

The first distillate from the tar described contains benzol, etc., and in greater proportion to the tar than similar distillate from coal tar. The intermediate distillate is of less value but has recently been reported a good fungicide by the Forest Service Investigators.

Because of the low free-carbon content and its differences in characteristics from coal tar, oil tar is frequently found in the manufacture of tar and pitch products in arriving at the results required.

On account of the large and growing demand for dust laying and road surfacing materials, however, the writer feels there need be no difficulty, at least for sometime to come, in disposing of oil tar for such purposes at a fair price.

WYANT: (After reading abstract of above paper) Regarding the formation of watery emulsion mentioned on page 17. While preparing this paper, a number of experiments were made to me which might throw some light on the formation of the emulsion, but the experiments could not be made in time to include them in the paper. They have since been made, however, and if interest in them warrants, I shall be glad to have Dr. Beardsley read them to you. These experiments were made and carried out by Dr. Beardsley, together with the aid of my assistants, Mr. Dunham, with much care. In the writing of the value of tar distillate as a fungicide on page 319, one of my assistants, who is interested somewhat in agricultural matters, tells me that it is a good fungicide but it kills the trees as well. (Laughter.)

CHAIRMAN: The paper is before you for discussion.

G. T. MACBETH (Mt. Vernon, N. Y.): I think the New Haven Gas Light Company is to be complimented, not only in the scientific way in which they have investigated their problem, but also on the cleverness with which they seem



to have been able to dispose of tar. I should like to ask Mr. Wyant one or two questions, however, in connection with the matter. Was there any perceptible change in oil per 1,000 ft. of gas made, when he changed from the use of hot or circulating water in his wash box and scrubbers to the emulsion? Also, is it not his practice to sell the tar from his works in a very hot state to the people who are putting it on the roads, so that the tar is spread more easily and better when it is hot?

MR. S. H. ELY (Dover, N. J.): I thought while we were talking on the question of the disposal of oil tar, it would be interesting to have brought to your attention a manner of disposing of this tar that, to my knowledge, has never been treated or spoken of at any meeting of the Institute. This is the use of oil tar in internal combustion or what are commonly called fuel oil engines.

The tar is used in the same manner as the fuel oil, being first heated and then put under pressure and sprayed into the engine with air at a pressure of about 1,000 lbs. per square inch. The engine is started on fuel oil and after it has been thoroughly heated through, the tar is pumped to the engine, sometimes by the same pump through which the fuel oil is fed, but more often by a separate pump.

The tar when mixed with the fuel oil thickens up like sour milk and sticks on the pump valves, making it necessary to use a separate pump. This method of disposal offers a very large field for oil tar sales and I believe, although I have not gone into it very thoroughly, that we could develop power in our own plants more economically by using the tar in the engines instead of in our steam boilers.

Those of you who are particularly interested in this phase of tar disposal, I would refer to an article in the *Gas Age* of August 1, 1914.

Before closing, I would like to ask Mr. Wyant if he is in a position to give us some idea of a tar distilling plant that could be installed in a small works and operated on a paying basis?

have sold a great deal of tar for road purposes in the state and find that if the dust is first swept from the (I am speaking now of macadam roads) and two applications made three weeks to a month apart, that it stands up well and in some places it has lasted all summer, having the appearance of amesite. It is put on cold, and answers the question of Mr. Macbeth.

C. BOONE (Brooklyn): Mr. Wyant's remarks bring to the attention of the oil tar problem which might properly lead to a little farther into the design of water gas generators. He particularly of the differing opinions among gas engineers as to the relative value of the several types of apparatus used in gas works for the removal of oil tars in all their varieties of composition and gravity. He describes very clearly, and shows by analysis, the variety of character of emulsion as it accumulates in the storage tanks, as he has found it. It is my opinion that this emulsion is a direct result of the action in the generating apparatus, and I feel it is caused by certain conditions there, which vary through the day's working, with all types and sizes of apparatus. Furthermore, all plants, except by chance, would be apt to make the same percentage of emulsion with relation to the oil used, and in balanced machines the percentage would vary in a general inverse ratio with the rate of make per minute. I feel confirmed from personal observation and study of the action of oil gas machines, that the variation in timing of oil treatment throughout the run, the selection of the path of the flow of oil gases through the generating apparatus, and the arrangement in the protection of these gases, over the entire area of the work, has much to do with the condition that causes the differing opinions of gas engineers as to the value of the apparatus used for separating purposes; though, as a rule, these effects are seen only in their average, and must be properly interpreted to be corrected.

Their opinions no doubt are based on what they actually see the apparatus do, but the duty imposed upon the apparatus



tus is to be accounted for at the point of generation. If the oil treatment is not uniform within certain reasonable limits, the duty of the apparatus must vary, and it may often be called upon to do work for which it was not designed.

It seems to me that a closer study of design with the idea of advancing toward automatically uniform treatment of the oil, from the beginning of a run to the end of a run, and throughout the period of the life of the fire, would bring about simplified and efficient separating arrangements, because of the uniformity of the product collected in the separating system. The tar produced would be of a more nearly uniform gravity, sufficiently heavy to be readily separated by simple treatment, and the emulsion would tend to disappear.

No doubt there will always be some upsets in the operation of gas plants, but anything which renders oil treatment more certain and more easily controlled must have the effect that I have tried to describe in these remarks.

MR. W. H. FULWEILER (Philadelphia): I should like to ask Mr. Wyant if he has any figures showing to what extent the water was reduced in the oil tar after passing through the scrubbers, or was the tar simply circulated until the water was apparently all driven off? It is a rather interesting idea that they have made the heat in the gas do this work, which at present has to be done from the application of external heat. There is another point that comes up. Has Mr. Wyant made any attempt to determine the change in the character of tar, as far as the presence, we might say, of undecomposed oil in the tar, whether he has noticed that it has any effect on the percentage of emulsion? This will be shown by the presence of high amounts of unsulphonated matter in the tar. Some experiments which we have made, seem to indicate a tendency on the part of tars containing a large amount of unsulphonated matter to more readily form emulsions, and we assume, maybe incorrectly, that the presence of large amounts of unsulphonated matter indicates incomplete cracking, and therefore irregular operation in the carbureter.

W. J. MCGURTY (New York): I would like to ask Wyant, at what percentage of the rated capacity of the removal apparatus, were those experiments conducted, that is at full capacity or at 60, 70 or 80 per cent. of this capacity? The tar recovery figure given, seems rather low, if a light oil was being used. I would like to ask if this is the case, or whether they use oils of varying gravity depending on the season of the year.

It might indicate a reason for emulsion formation, since we have found that even when operating without the scrubbers, emulsion has been produced, after having operated for months without producing any, showing the possibility of incomplete separation of the oil.

J. H. TAUSSIG (Philadelphia): I would like to ask Mr. Wyant the approximate temperature at which he carries the different parts of his apparatus. The amount of tar carried over is a function of the temperature. It would be very interesting to know his operating conditions.

THE CHAIRMAN: Won't you add your experience, Mr. Taussig, covering the points set forth in the paper?

TAUSSIG: It seems to me there is a surprising amount of tar going through the P. & A. extractor. It may be that the extractor has not a high enough differential to take out all the tar, or the holes may not be set exactly right, but the efficiency is very poor. With temperatures below 105° F., over 90 per cent. of the tar should be removed. It is possible that the extractor that is carried over that temperature might allow tar to go through in the form of saturated vapor and be subsequently condensed. I have had experience with the emulsion. It seems best, where there is large storage available, to allow the tar to settle out. This takes considerable time, but it is a successful method with me.

A. H. ELLIOTT (Flushing, N. Y.): I should like to ask Mr. Wyant the gravity relation between the oil gas tar and the oil tar used. With some light oils you won't get very much tar out with heavier oils that you are compelled to use nowa-

days, you will get a good deal more tar than I think he does there, unless he is very fortunate. I think that it is nearer 20 per cent. than it is 14. I want to make a suggestion to Mr. Wyant, and that is, that when they are testing the tar by distilling or when they are making these separations on the oil emulsions, they should apply one of the methods for separating the paraffin hydrocarbons from the aromatic hydrocarbons, and that will give a clue to the amount of oil that has actually been decomposed. An oil that has been heated at low temperature, of course will go through as a paraffin oil, or one of the paraffin series, while the oil that has been heated, say around 1,000 or 1,200 degrees and above will be more likely to belong to the aromatic series. These are only suggestions along the line of new work, and I hope that they will be accepted as such.

MR. A. S. MILLER (New York): I think undue difficulty is placed around this question of separation. In all my experience, extending over the use of a good many different kinds of oils, I have never seen the time when a properly designed separator run at the proper temperature, would not separate the tar to a point where it would contain not over 2 per cent. of water, and I do not think there is any difficulty whatever in that line. Of course, running with oil in retorts, the situation is somewhat different. I do not know whether anyone runs that way now or not, but it does seem necessary, when you are using the oil in retorts, to separate out the carbon before the residuum oil will separate from the water. The residuum oil can be separated from the water by putting it through a filter press and separating out the carbon, but with the Lowe process, or any modifications of it, with widely varying types of oil—I have used oils varying from 63 to 20 degrees—I have never found any serious difficulty in separating the water from the tar and the tar from the water.

MR. C. H. HODGES (New York): In the plant with which I am associated, we simply take the emulsion and pass it through the tar separators a second time. Until about seven

ago, we used to accumulate a great deal of this emulsion, it was taken away by someone, I think for nothing. Since we haven't had one ounce to give away; we put the emulsion through a second time and that solved the whole problem.

J. A. NORCROSS (New Haven, Conn.): I should like to say one more word. We have put in a good deal of work on the problem of the emulsion formed in carbureted water gas, and we have found out something about it. One of the speakers suggested that if the emulsion were allowed to settle in a large tank, such as a relief holder tank, it would separate in time. We have, in addition to the relief holder tank, a 10,000 gallon holder steel tank, and that tank was previously full of tar. When we came to burn that tar, or sell it, we discovered that it was an emulsion; a very little tar would separate in a very long time and find its way to the bottom. As Mr. Wyant has described, the proportions of water in the emulsion varied from about 80 per cent. water at the top to all tar at the bottom, and only a few inches from the bottom was a large percentage of water. Now our problem is to get rid of the emulsion. We have made some progress along that line, but a very disappointing feature of our investigations is that we do not know the cause of the emulsion, though the results of the experiments which Dr. Beardsley will describe shed some light on this subject. The suggestion that it is due to the generator conditions, does not seem to apply. Our apparatus has been the same for many years. It is standard apparatus for the manufacturing of carbureted water gas. There have been no changes in the oils; there have been changes in the methods of operation; in other words, where we used to have long runs and short blows, we now have shorter blows and more runs; and the suggestion of one speaker that the increased capacity per square foot of grate area of generator, or the minute of the generator would prevent emulsion, does not seem to hold, because our accumulation of emulsion occurred for years when we have been running with increased output from the generator per square foot of grate area.

MR. R. S. SCOTT (Baltimore): We have had some trouble in past years with oil tar emulsion when on high oil per M, but our experience leads us to believe that its formation is due to unbalanced conditions in the generating apparatus.

MR. NORCROSS: As evidenced by what?

MR. SCOTT: The time of blowing relative to the time of gas making.

MR. NORCROSS: What is this unbalance? I do not understand.

MR. SCOTT: I mean that a better balance should be established between blowing time and gas making time, in order to reduce the range as far as possible between maximum and minimum heats in the checker work, while the stain papers at the outlet of superheater show the heats established in the checker work to be the correct heats for the oil being used, as determined by a series of stain papers at the superheater giving a proper uniform stain throughout the entire run of oil into the carbureter. Unbalanced conditions also come from improper handling of fires, a poor balance of up and down steam, too much excess steam, or possibly defects in the apparatus. With unbalanced conditions, the oil tar emulsion appears to be formed by the fact of the temperature of the checker work being too high at the first part of the run, thereby over-cracking a quantity of the oil and forming lamp black, while at the latter part of the run the heats are too low, resulting in under-cracking a quantity of the oil.

Such conditions coupled with excess steam tend to produce an emulsion of porous lamp black absorbing oil and water vapors, which upon condensing, appears in the seal pots and tar separators as a liquid emulsion consisting of lamp black, oil and water. The union of these substances is a very close one requiring a distillation to separate them.

The checker brick has its limitations, and if conditions of operating necessitate running with high oil per M, it is extremely difficult to entirely eliminate the formation of emulsion, but the quantity made can sometimes be reduced by ar-

ing the relation between the blowing time and running to better advantage, while adjusting the steam with the of keeping the excess steam down to a minimum. We find it is best to preheat the oil, using exhaust steam, being that it at least gives a better distribution of the oil into carbureter, thereby giving more uniformity in cracking oil.

We use the tar separator tank as an indicator or check on heat, balance of the gas machines, and the chief gas maker pays much attention to the behavior of the tar separators. He does to his fires, heats, oil sprays, steam papers, seal pots, cleaning, cleans, or to any other part of the gas making routine. We keep the bottom of the separator tanks as clean as possible, comparatively free from accumulated tar. We have in our tar separating tank a partition that goes within about 18 inches of the bottom, and if we allow more than about 18 inches of tar to accumulate at the bottom of this tank, the velocity of the saturated water passing under the partition is increased sufficiently to have a stirring effect, and no additional tar will separate out until the bottom is cleared of tar. For effective tar separation, comparatively slow vertical travel is required in the separating tank, as the process of separation consists of a quiet undisturbed settling of the tar out of the water. We are fortunate enough to get very clean tar separators. Our separators are of ample size for the amount of gas made, and by examination of the overflow water from the first tank or main separator, we find over 99 per cent. clean, reported by our chemist from time to time, while each separator make runs from 0.4 to 0.7 per cent. of water.

While first assuming all other things equal, those conditions of the gas generating apparatus which produce the best results at the tar separating system for settling out good clean gas also appear to produce the best gas results, both in calorific and candle-power values per gallon of oil used. It, therefore, appears that clean tar recovery is of vital importance to economy, and I may add that we appear to get the best oil efficiency when we do not observe any emulsion being made.

Under our present conditions of operating, or while running on low oil per thousand, we are not apparently making any emulsion, nor have we seen any being formed for the past six months while on low oil, and we find the tar separating system gives us material aid in establishing and maintaining an effective heat balance in the generator sets for the proper handling of the kind and quantity of oil being used.

MR. C. J. RAMSBURG (Chicago): Some one has said that people may be divided into two classes, those that have rheumatism, and those that are going to get it, and I think that before I heard Mr. Scott's speech, I would have said that people who make water gas are divided into two classes, those that do have trouble with emulsion, and those who are going to get it. I do not know whether Mr. Scott is storing his water gas tar at all or selling it. If he is storing it, I think he will find, if he is storing it in his relief holder, that he has not reached the point yet at which he finds that he is making emulsion. The Philadelphia Gas Works has been through a series of experiments with this emulsion; they made a great many analyses, and they finally found that they had confined this emulsion to a certain amount of iron in the tar. They also found that if they put water gas through a coal gas plant, putting in water gas tar that had no water in it, that the coal gas tar would be an emulsion which you could hardly store unless by distilling it. I got out of touch with the work that was going on in Philadelphia about a year ago, but I know that the thing has been prosecuted to a conclusion.

MR. D. W. FLOWERS (St. Paul, Minn.): I want to ask Mr. Wyant if he pumps this emulsion through his seal-box as well as through the scrubber, and if he pumps through the scrubber only, I want to ask him where he gets the heat to evaporate his water?

MR. G. H. WARING (Charleston, S. C.): There has been so much already written about this subject, but it seems the most interesting part of this paper is the question of emulsion,—how to get rid of the emulsion after you have got it. I can-

not give any experience on this, but as to the question of how to make emulsion, I believe I can give you some information. (Laughter.) By knowing how to make emulsion, probably you can draw conclusions how not to make it. If you want to make emulsion, put cold water in your wash-box, put cold water through the scrubbers, and you will get emulsion. At the present time, we are not doing this. (Laughter.) We are pumping hot water through our wash-box, and using no water in our scrubbers. The temperature of the wash-box, that is, the temperature of the separating system, is never allowed to go below 150 degrees. And we have had no trouble, as we have said, with emulsion, and we feel sure that the whole trouble in this emulsion matter is due to using cold water in the circulating system. We do not use any other water in our wash-box, except the water pumped from the separators. This water merely circulates around, and will retain the temperature of 150 degrees in a climate where the temperature reaches as low as 25 below zero, provided the separator is covered. Getting rid of this emulsion, I imagine, could be done by pumping it through as has been suggested. I agree with what Mr. Miller has said on the subject.

MR. TAUSSIG: I don't think that by carrying the separator temperature above 150 degrees, as Mr. Waring states, will prevent emulsion in all cases, as I have made considerable of it with the separator above that temperature.

MR. BOONE: I was going to add to Mr. Waring's remarks, that he might transfer that system of putting cold water through the apparatus a little nearer to the beginning of the process, and put it through the generator in the shape of too much steam to the fire. He need then merely to keep his superheater checker brick sufficiently hot and he will have emulsion, and plenty of it. In other words, a combination of low fire heat and hot superheater checker brick heat with light tar, will produce the breakdown, a combination that will not separate easily unless you give it the treatment that Mr. Miller spoke of.



MR. RAMSBURG: Is it not possible that the term "emulsion" is being confused, Mr. Wyant speaking of emulsion that occurs on top of the relief holder and Mr. Scott speaking of emulsion that occurs in the separator while trying to separate the tar as originally made. It seems to me what Mr. Norcross and Mr. Wyant are speaking of, is the trouble they got after they found out that they had the relief holder full of tar and commenced to try to burn it up, and Mr. Scott is talking about merely the operation in the separator.

MR. SCOTT: We store our tar until we have accumulated a 500,000-gallon tank load. Shipments in such lots accumulated over a period of about three months show not over 0.7 per cent. of water. Upon examining the bottom of the 500,000-gallon tar tank after a shipment in May last, we discovered some emulsion, but only a very small quantity of the total amount of tar that had been previously stored in this tank, and we believe that most of this emulsion was made while we were enriching coke oven gas and, therefore, running on high oil per M. The emulsion found in this tar tank, upon distillation proved to be of the same character as that found in the relief holder in past years when we used that very undesirable place for tar storage, when running the high oil per M. I jotted down a few notes regarding some characteristics of emulsion collected from various places of storage in the past, when we were making emulsion while using high oil. We found that the lighter oils below 338° F. ran from 5 to 10 per cent., at a gravity of 0.90 to 0.95; middle oils, 338° to 518° F. from 10 to 20 per cent., with a gravity of 0.97; and anthracine oils above 518° F. from 10 to 15 per cent., having a gravity of 1.030. The water content varied between 40 to 60 per cent., and the residuum ran between 10 to 12 per cent.

THE CHAIRMAN: Is there any gentleman who wishes to add to this discussion?

MR. J. P. KENNEDY (Cambridge, Mass.): Mr. Scott has not told us what disposal he made of the tar which he had stored in the 500,000-gallon tanks. And as to that, I see Dr.

sitting over here, and I think he could give us some information on the question. It would be very useful.

SCOTT: Did you say the tar itself, or emulsion?

KENNEDY: As regards the tar, or whatever it is or be in the 500,000-gallon tank which you have for sale, object to saying what you sell it for—for what purpose?

SCOTT: I don't know. We simply sell the tar which cumulate in 500,000-gallon lots. I don't know what the users do with it.

KENNEDY: In other words, you sell the tar and sell it some water in it?

SCOTT: No, I meant after pumping the tar out of the tank, some emulsion remained. The amount of emulsion, however, was an infinitesimal proportion of the total amount that this tank had stored before the bottom was cleaned of emulsion. The emulsion found was just a thin layer on the bottom of the tank, possibly an inch or more; we did not remove it.

KENNEDY: I thank you for the answer. I would ask you to state what he knows on this tar subject.

TAUSSIG: I should like to ask Mr. Wyant whether his tank formed in his separator. When I was making emulsion some years ago, it seemed to form in the relief holder when pumping from the separators. It either came down the relief holder, or got mixed up in pumping.

J. F. WING (Everett, Mass.): I am afraid I cannot give much positive information on this. It is all negative. I have often been stuck to know what to do to handle the product. We get about 10 per cent. of the tar from the settling tank as a lean, slimy, sludge, which is very hard to handle under our usual arrangements, because it settles so on any coil at the bottom of the tank, and cannot be separated. As a matter of fact, we dispose of it by shovels. Some of it was put out in a 12-in. pipe for a test with plenty of steam coil put around it to allow us to separate that sludge, which in our case has about 40 per cent. of water, and the sludge contains about 3

per cent. of ash when it is burned. Now this ash is very finely disseminated through the tar, and is apparently the whole cause of the emulsion; it prevents the emulsion from settling. When we settle this with a sufficiently long and high heat, we can get tar from this mixture, but the sludge that we get then is still worse. That, when cooled, can be shovelled with considerable difficulty. I wish I could tell you something that would help, but I can only speak of difficulties.

THE CHAIRMAN: Would you explain the disposal of the sludge?

DR. WING: The sludge is pumped into breeze, that we are fortunately able to get from a neighbor, and just mixed with a locomotive crane bucket and burned. It can be handled quite successfully, but it takes nearly all our boiler capacity to burn it off at a moderate rate to get rid of it without smoke.

MR. HODGES: I should like to ask Mr. Ramsburg, if I understand from his remarks that you cannot separate all the emulsion, especially holder accumulation?

MR. RAMSBURG: I may not have expressed the idea clearly, but my point is, that no one has trouble with emulsion until they try to sell more tar than they make. (Laughter and Applause.) An analysis of the tar in your relief holder shows that you had an abundance of tar with 2 per cent. water. Above this, though you do not realize it, is an emulsion with 75 per cent. water, which appears like good tar and you assume it is. A condition arises which causes you to sell the lower strata of good tar, and some morning you wake up to find that the only place you have any stock of tar is on the books.

I do not say that Mr. Hodges cannot separate the emulsion out of the tar, but after the emulsion has been pumped into the relief holder, then your troubles begin when you try to sell the tar.

MR. HODGES: Accumulation in an old holder recently dismantled was separated by periodically admitting daily a portion to the separators.

MR. NORCROSS: Dr. Beardsley has made some interesting

iments, and I think he has a memorandum with him. I  
 d be very glad if we could have that read to go in the  
 FEEDINGS.

A. P. BEARDSLEY (New Haven, Conn.): The mixture  
 of tar and water, which we are in the habit of calling an  
 emulsion, is probably not an emulsion in the true sense of the  
 word, but a suspension of tar and water. A true emulsion  
 consists of two mutually insoluble liquids, held in permanent  
 suspension through the agency of a third liquid in which each  
 of the first two is soluble. There seems to be no such third  
 liquid present in this case. Furthermore, given long periods  
 of time, the tar mixture will separate, partially at least, into  
 water and tar with less water content. Samples of a mixture,  
 containing 75-78 per cent. of water, were drawn from the  
 storage tank, which serves as a water gas tar storage, on July  
 1914, and stored in 2-quart cans for about two months.  
 At the end of that period, it was found that approximately a  
 third of the water had separated above the tar and that the latter  
 contained 55 per cent. of water. These cans had stood undis-  
 turbed in a room of even temperature, so that the material was  
 not subject to movement due to uneven external temperature  
 variations. The depth of material was small, which would  
 not further assist separation; yet, only partial separation took  
 place. These facts show the persistency of the emulsion, and  
 indicate that no effective separation by settling can be ex-  
 pected where the emulsion is contained in a large tank, subject  
 to movement by temperature changes, by pumpings in and out,  
 or if the tank is that of a gas holder—by the rising and  
 falling of the holder lifts.

Three factors suggest themselves, which may assist in the  
 separation of this emulsion.

- A. The amount of contact or agitation with water which  
 the tar receives.
- B. The nature of the tar itself.
- C. The amount of suspended particles in it—dust or  
 free carbon.

These factors will be considered in order.

First: To learn what effect agitation would have on a tar which ordinarily separates comparatively free from water, a vertical retort tar, containing 4 per cent. of water and presumably about 6 per cent. of free carbon, was shaken violently in a shaking machine with its own volume of water. An emulsion resulted from which only a trifle of water separated after several weeks' standing.

In the case of water gas tar emulsion, however, agitation is at best a secondary cause. Emulsion is formed in simple condensation without agitation, as is shown by the following experiment:

Gas was taken from the take-off of a water gas set, above the seal pot, and passed through a small condenser. The condensed tar after standing two weeks, was separated by appearance into clear tar and emulsion. Of the total volume of tar and emulsion, the emulsion comprised 8.37 per cent. The clear tar contained 0.87 per cent. of water and the emulsion 35.25 per cent. The tar and emulsion combined contained 3.75 per cent. water. Of the total quantity of tar obtained, calculated free from water, 5.63 per cent. was emulsified. Not all the tar in the gas was obtained by this simple condensation, as the cooled gas was still foggy. The temperature of condensation was 83° F. It would be desirable to know what portion of the tar which separates out in the board scrubber appears as emulsion. Unfortunately this cannot be determined at present, because emulsion is being circulated through the scrubbers.

A sample of the tar flowing from the tubular water gas condenser was also allowed to settle for three days. It was separated by appearance into:

82.7 per cent. clear water.

17.3 per cent. emulsion, containing about 50 per cent. of water.

This percentage of emulsion of course does not indicate that present in the whole tar, but only in this portion of the tar.

nd: To learn what effect the nature of the tar and emulsifying liquid might have, the following experiments in the artificial production of a tar emulsion were tried. A water gas tar containing 1 per cent. of water was used as a base and a vigorous shaking by hand for five minutes was made in the following experiments:

Twenty-five parts tar and 50 parts city water, shaken together, separated quickly and clearly.

Crude naphthalene crystals were mixed with enough benzol to form a mush. Ten parts of this were added to 40 parts tar and well mixed. Fifty parts of the mixture were shaken with 50 parts water. No separation took place.

Fifty parts of the naphthalene mush were well shaken with 50 parts water, and this mixture shaken with 50 parts tar. No separation took place.

Fifty parts benzol were shaken with 45 parts water, and this mixture shaken with 50 parts tar. No separation took place.

Fifty parts naphthalene crystals were shaken with 45 parts benzol and the mixture shaken with 50 parts tar. No separation took place.

Fifty parts benzol were mixed with 45 parts tar, and then this mixture shaken with 50 parts water. A quick, clean separation took place.

Fifty parts naphthalene crystals were mixed with 45 parts benzol and shaken with 50 parts water. A quick, clean separation took place.

Summarizing these experiments, it would appear that small amounts of benzol or naphthalene if added to the tar itself have no effect, but if added to the water first, result in the formation of emulsion. It may be that in the latter case, the particles suspended in the water serve as nuclei for the formation of globules. We can imagine that some such conditions may exist in the scrubbers and condensers of a water gas plant and may partially account for the production of emulsion.

In one of the above experiments, an emulsion was formed, when a comparatively large amount of mixed benzol and naphthalene was added to the tar first and then shaken with water. It seems likely that in this case there was more naphthalene than the tar could dissolve, and that fine crystals in suspension served the same purpose as nuclei.

Third: To learn the effect of solid particles in suspension, the following experiments were performed. An emulsion previously mentioned, which originally contained 75 per cent. of water, and after standing two months, still held 55 per cent. of water, was the material used. A considerable portion of this was freed from water and from light oil, by distillation up to 390° F. The residue was diluted with carbon bisulphide and filtered from free carbon, after which the carbon bisulphide was distilled from the filtrate. The light oil obtained in the first distillation was added to the carbon-free residue, giving the original tar, except for the free carbon. The amount of free carbon originally present was 2.20 per cent. of the whole tar. The tar, after extraction, was found to contain 0.017 per cent. carbon, showing a practically perfect separation.

With this carbon-free tar, the preparation of emulsions was tried. Since the original proportions had been 45 parts of tar to 55 parts of water, these same proportions were retained. Agitation was done on a shaking machine and lasted three hours. The results follow:

1. Forty-five parts tar and 55 parts city water. This separated to 40 parts clear tar, 12 parts emulsion and 48 parts clear water.
2. Forty-five parts tar and 55 parts of the water which had been distilled from the original emulsion. This separated to 40 parts tar, 25 parts emulsion and 35 parts clear water.
3. Forty-five parts tar and 55 parts distilled water. In this, the lower layer was not well defined. The mixture separated to 80 parts of an emulsion apparently rich in tar at the bottom and in water at the top, and 20 parts clear water.
4. Forty-five parts tar and 55 parts distilled water with

h had been shaken 2 parts benzol. This separated to  
t 33 parts clear tar, 40 parts emulsion and 27 parts clear  
r.

Forty-five parts tar and 55 parts distilled water with  
h had been shaken 2 parts by weight of lamp black. Com-  
emulsification took place. There was no tendency to  
rate.

Forty-five parts tar and 55 parts city water with which  
been shaken 2 parts by weight of lampblack. Complete  
sification took place. There was no tendency to separate.  
hy the city water should separate so much better than the  
led water, it is difficult to say, except that it naturally  
be connected with the presence of dissolved salts in the  
water. In the condensation of water gas we are con-  
d, however, with distilled water—that is, with the excess  
n which is put under the generator.

In general, these experiments show that the presence of even  
all amount of free carbon is almost a deciding feature in  
ormation of emulsion. While some emulsion was formed  
all the mixtures enumerated above, nothing like a com-  
and permanent emulsion was formed except when lamp  
was used.

We feel inclined to summarize our conclusions as follows:

Some emulsion will be unavoidably formed in the scrubbing  
condensation of water gas, for it is impossible in practice  
back the oil without the formation of some light oil and  
lamp black, due to the varying temperatures during the  
Too low heats allow the passage of uncracked oil, and  
high heats increase the proportion of lamp black, both of  
n tend to the increased formation of emulsion.

R. WYANT: I am pleased with Mr. Macbeth's question.  
ould say that we have not observed any change in the oil  
encies due to circulating the emulsion through the scrub-  
Regarding the sale of the road oil, we do not need to sell  
t, because the density at which it is prepared makes it



thin enough to penetrate into the dust of the roads very readily when sold.

In regard to Mr. Ely's question as to small distilling plants, for road oil, I would suggest simply a horizontal cylindrical tank with steam coils, also a pipe leading down into the tank from the outside, which introduces the steam, which is blown into the tar when hot. The cylindrical tank or seal would require a take-off which can be passed through a condensing coil. The condensate could be then readily saved and separated, as it separates very readily from the water.

Regarding the formation of the emulsion, I think Mr. Beardsley's experiments state all that I have to say. I believe that emulsion is always formed to some extent in a water gas set. It is not necessarily due to the varying temperatures from hour to hour in the carbureter, or superheater, but it is due to the constant change in temperature in these parts of the apparatus during each run. You cannot maintain anything like a uniform temperature during a run, and you have on every run conditions which tend to produce the light oils and lamp black, which simply emulsify with the tar on condensation. I think that is the whole story. You may make more or less, but you cannot entirely avoid it.

Regarding Mr. Fulweiler's question as to the reduction of the water in single passes through the condenser, I have no information. We simply fill up the receptacle from which we circulate the emulsion and collect the tar, and keep it going until we effect separation. As I stated, it amounts to about 1,000 gallons of the emulsion per 1,000,000 feet of gas, and that might be based on apparatus having 1,000,000 cubic feet capacity in 24 hours.

Mr. Taussig asks the temperature at which the gas is carried at the P. and A. extractor. This temperature ranges between 100 to 110 degrees. During the series of tests, we found considerable variation in the efficiency of the P. and A. extractor in removing tar, but that efficiency varies very greatly with the relative capacity of the P. and A., and the quantity of gas

g. It needs to run, to do its best work, at its full  
 ty, so that it will work with a large differential pressure,  
 s I stated in my paper, we cannot always operate this  
 atus under the best and most economical conditions.  
 fore, the efficiency we found was an average of 80 per  
 We found some tests above 90 per cent.

Taussig also asks whether there was any emulsion in  
 parators, or water which flowed from the relief holder.  
 r case all the emulsion that has been made passed through  
 parators. There seems to have been some misappre-  
 n as to the large quantity of emulsion that we have. I  
 that has been cleared up. It is not a question of the  
 ty with the emulsion we are now making, but it is  
 fficulty of getting rid of the emulsion that we have been  
 g and storing for the last 10 years.

R. NORRIS (Philadelphia): I move a vote of thanks  
 c. Wyant for his very interesting and most discussion  
 king paper.

motion was seconded and carried.

## POINTMENT OF SECTIONAL NOMINATING COMMITTEE.

E CHAIRMAN: The procedure under the new Constitu-  
 will require that the Manufacturing Section proceed to  
 ate or nominate three candidates, from whom one will  
 ected by the Nominating Committee next year as a can-  
 for Vice-President, and one of the functions of the  
 President so nominated and elected will be to preside  
 the sectional meetings of the Manufacturing Section.  
 s there is objection raised in this section meeting, the  
 will appoint a committee of five, and ask them to report  
 morrow's session to this section, their selection of these  
 names. If any appointee is not going to classify himself  
 the Manufacturing Section, I hope that he will so in-  
 the Chair at once, so that a substitute can be named. In  
 words, I assume that the five men that I now name are

going to vote and act in the Manufacturing Section. I will appoint as this Committee:

W. Cullen Morris,  
A. H. Strecker,  
Rollin Norris,  
W. A. Wood,  
Carroll Miller.

I will ask for a report at to-morrow morning's session.

The next paper is "Coal Gas Residuals—Feld Process," by Mr. F. H. Wagner, of Baltimore. I will ask Mr. Wagner to condense to what extent he can the summary of the paper so that we can have more time for discussion.

#### COAL GAS RESIDUALS—FELD PROCESS.

A hundred years of development have passed since Murdoch lighted the City of London with coal gas, and these years have placed gas lighting in the fore-front of industrial progress, while the history of these years plainly shows how the proper utilization of by-products can revolutionize the magnitude of an industry. The early years of coal carbonization could depend upon no, or but very little, assistance from by-product sales in the matter of cheapening the cost of production, and not until the aid of modern chemistry was called in, did the production of residuals make any appreciable change in this condition.

The recovery of residuals is a very important conservation of resources, and it forms one of the principal means of revenue to the coal gas producer, the sale of these residuals reducing the cost of gas production in a degree corresponding to the efficiency of the recovery methods adopted and the market value of the product.

The principal residuals recovered to-day are tar, naphthalene, cyanogen compounds, ammonia, and, in the case of coke oven gas, also benzol by a direct recovery method, and they will be treated in this consecutive order in the following pages; the recovery of benzol is confined almost entirely to

the coke oven plant, where a direct method of recovery is adopted, and to the tar distiller, benzol being one of the most valuable of tar constituents. While the recovery of naphthalene cannot exactly be termed one of profit in a pecuniary sense at present, the removal of a certain portion from the gas is of distinct advantage, and the methods adopted for its removal will, therefore, be given.

The gas produced during the carbonization of coal is a mixture of fixed gases, vapors of various kinds, and, at times, also globules of liquids, which are held in suspension, and are thus carried forward by the gas; these gases and vapors also carry forward some solid carbon in the shape of dust.

The principal fixed gases are hydrogen,  $H_2$ ; methane,  $CH_4$ , also known as "marsh" gas; ethane,  $C_2H_6$ ; propane,  $C_3H_8$ ; butane,  $C_4H_{10}$ ; ethylene,  $C_2H_4$ ; small amounts of butylene,  $C_4H_8$ ; propylene,  $C_3H_6$ ; acetylene,  $C_2H_2$ ; carbon dioxide,  $CO_2$ ; carbon monoxide,  $CO$ ; hydrogen sulphide,  $H_2S$ ; nitrogen,  $N$ ; oxygen,  $O$ ; and ammonia,  $NH_3$ ; while the principal vapors in the mixture are benzol,  $C_6H_6$ ; toluol,  $C_6H_5CH_3$ ; xylol,  $C_6H_4(CH_3)_2$ ; carbon disulphide,  $CS_2$ ; and aqueous vapors. These latter vapors all pertain to substances which become liquid at ordinary temperatures, but the vapors of naphthalene,  $C_{10}H_8$ , phenols, etc., pertain to substances which become solid at ordinary temperatures, and must, therefore, be subjected to a special treatment.

As will be seen later, some of these constituents are of inestimable value to the coal gas producer, and consequently the treatment of the gas after it is produced in the carbonizing plant, is of great importance; this treatment should not only consist of a method of cooling the gas, and thus condensing and precipitating the vapors as a fluid, but the method of treatment should be such as to retain in the gas those valuable illuminating constituents which may be lost to a greater or lesser extent in the usual condensing plant.

The Feld system of condensation and purification of coal gas, which embraces successive cooling with a fractionation

of the products, appears most attractive from the standpoint

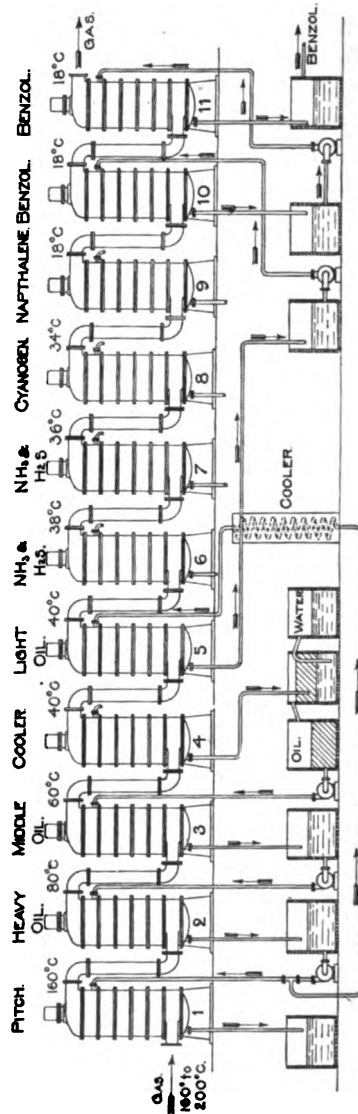


Fig. 1.—Feld condensing plant.

of efficiency and simplicity.

The usual condensing system in coal gas practice embraces the use of a primary condenser, exhauster, tar extractor, secondary condenser, and ammonia washer; the tar, together with quite an amount of illuminants, being thus removed in a greater measure by cooling, while in the Feld system, the gas is not cooled below a point where any volatile hydrocarbons are precipitated or absorbed by the effluent, the tar being fractionated in three washers into pitch, heavy oils, and middle or light oils, and the gas is treated for cyanogen compounds, combined hydrogen sulphide and ammonia, naphthalene, and finally benzol, the entire process being carried out in Feld vertical centrifugal washers, as shown in Fig. 1.

As will be seen from Fig. 1, the entire condensing plant consists of eleven washers, the first, or pitch washer operating at a temperature of from  $320^{\circ}$  to  $392^{\circ}$  F., the gas being kept at this temperature from the hydraulic main by insulating both the main and the pipe connections, or by the application of external heat, heavy oils from washer (2) being pumped into washer (1) where they are used as the active pitch extracting medium.

Washer (2) removes the heavy oils, and it is operated at a temperature of from  $320^{\circ}$  to  $176^{\circ}$  F., all operating temperatures being determined from the actual dew-point of the gas for the constituent to be removed, the extracting medium being the middle oils from washer (3).

Washer (3) removes the middle oils, due to contact between the gas and the oils separated by cooling in washer (4), this cooling being effected by bringing the gas into intimate contact with water, the effluent from washer (4) being run into a separating tank where the oil is separated from the water by specific gravity.

The light oils are removed in washer (5), where the gases are washed by means of heavy oils which are previously cooled in a special cooler, these oils from (5) being run into a reservoir from whence they are pumped into the first benzol washer.

The washers for ammonia and hydrogen sulphide operate under a temperature of from  $104^{\circ}$  to  $97^{\circ}$  F., the hydrogen sulphide being combined with the ammonia in these washers with the consequent formation of ammonium sulphate, while the cyanogen washer operates at about  $97^{\circ}$  to  $93^{\circ}$  F.

The naphthalene is removed in washer (9) at a temperature of about  $65^{\circ}$  F., while washers (10) and (11) serve to extract the benzol and its homologues, the partially saturated oil coming from washer (10) being pumped into washer (11).

When this paper was contemplated, it was the desire of the author to treat each residual in a more exhaustive manner, but owing to the large amount of data prepared, the contents passed beyond the bounds of a paper of this character, and consequently it became possible to herewith present only the more essential features of residual recovery and the possible profits which might accrue due to the adoption of modern methods of operation.

#### TAR.

Tar is a thick, dark brown, viscid, oily liquid, produced during the dry distillation of coal; its chemical nature is very complex, and it contains a large number of compounds. The crude gas leaving the retorts is a mixture of permanent gases, but this mixture carries with it quite a number of hydrocarbon and other vapors, and as the illuminating, as well as the calorific, quality of coal gas is, in a great measure, dependent upon its hydrocarbon constituents, it is of prime importance to so treat the gas as to retain as many of these hydrocarbons as is possible. A reduction in temperature, however, soon reduces the hydrocarbons of greater density to liquid form, and this liquid is usually termed "tar." In spite of the fact that the gas temperature at the hydraulic main outlet is perhaps never lower than  $145^{\circ}$  F., large quantities of tar are deposited at this point, and it is, therefore, almost impossible to retain the hydrocarbons of this class in the gas with the usual method of condensation.

Both the nature of the coal used and the temperature of

carbonization exercise a great influence upon the quantity, as well as upon the quality of the tar produced, thus both quantity and quality regulating the amount of revenue received, and in this manner, governing, to a great extent, the final cost of gas production.

In the usual systems as applied at present, the removal, or the precipitation of tar, is accomplished by condensation or cooling; quite an amount of condensation occurs between the retort and the hydraulic main, a further amount of tar being deposited in the hydraulic main proper, after which the gas is conducted to the condensers where gradual cooling further reduces the tar content. After leaving the condensers, the gas still contains quite a number of tar globules in suspension, it being possible to remove only these last traces of tar by means of friction.

In the Feld system, a different method is employed as the heat contained in the gas is utilized by a system of fractional coolings to separate, or wash out of the gas, tar in several of its principal constituents. This treatment may also be varied in such manner as to prevent the formation of tar as much as possible by maintaining the heat of the gas coming from the retorts at a temperature above the dew-point of the gas for the constituents of high boiling points. This may be done by covering the connections from the retorts to the first washer with insulating material, or by applying heat to the exterior of the pipes. The gas thus protected is led to the washers where it is subjected to fractional cooling and successive washings at successively lower temperatures, so that the various tar constituents are separated from each other by employing the temperature of the gas itself, and without the necessity of employing extraneous heat after previous cooling.

A Feld washer especially arranged for hot tar washing is shown in Fig. 2, and in order that aqueous condensation may be avoided in the washer by reducing the temperature of the gas to the dew-point for water, the washing tar should be heated to from 40° to 60° F. above the temperature of the



gas at the inlet to the washer, this hot tar being the active tar extracting medium.

Referring to Fig. 2, which shows a portion of a Feld washer with superimposed Pelouze condenser,

- A = Pelouze Condenser.
- B = Gas port in washing chamber.
- C = Upper washing chamber.
- D = Lower washing chamber.
- E = Gas inlet.
- k* = Basin, or tank containing wash tar.
- r* = Radiator, or steam coil.
- l* = Rotary tar pump.
- m* = Preheater for wash tar.
- s* = Insulated connection from tank (*k*) to pump (*l*).

In order to keep the wash tar at the desired temperature the steam pipe from (*m*) is located beneath the pipe (*s*).

The hot wash tar is pumped from tank (*k*) through the insulated connection (*s*) and preheater (*m*) to the Pelouze condenser (A) through the overflow pot (*n*); any surplus tar overflows at (O) and (*p*) and returns to tank (*k*).

The tar overflows from the Pelouze through (*b*) and (*d*) (*e*) and (*g*) into the upper chamber (C) of the washer where it is picked up by the washing cones within the chamber and spread out over the entire gas space, the depth of the spray being from 8 in. to 14 in., depending upon the size of the washer. The gas is thus brought into intimate contact with the hot wash tar, and is subjected to a thorough washing the wash tar as well as the tar expelled from the gas, overflowing through the gas port to the next lower washing chamber; here the wash tar is again placed in circulation by the cones in this chamber, and the total combined tar finally leaves the washer through the pot (*i*) attached to the gas inlet connection, and by means of overflow (*h*) enters tank (*k*), all surplus tar from this tank flowing off to the tar storage.

In order that the maximum results may be secured, the wash tar should be constantly circulated through the washer, but it is not always necessary to circulate it through the





size condenser, this omission being dependent upon the position of the tar in the gas. The amount of hot tar to be circulated through the washer may vary from 0.5 to 2.5 gallons per 1,000 cubic meters of gas per hour; larger volumes of gas require proportionally less circulating tar than do smaller volumes, but the amount of washing tar circulated must be so regulated as to prevent the temperature of the gas reducing the temperature of the wash tar.

The circulating wash tar should be pumped through the preheater (*m*) before it enters the washer, this preheater being supplied with a steam coil, and in some cases it may be necessary to insulate the tank containing the wash tar, depending upon its location, and even the washer proper with insulating material, in order to increase the efficiency. Many of these washers are set up in the open in Europe, and are thus exposed to the weather.

The tank containing the wash tar is also provided with a steam coil, or radiator, made in one piece in order to prevent leakage and thus mix water with the tar. Care must be exercised in operation to the extent of preventing the deposit of tar in the Pelouze condenser, and if the washer should stop for any reason, it must be emptied of tar at once in order to avoid cooling the tar and thus clogging up the passages.

Table I gives the results secured in washing with hot tar, the washer being supplied with a Pelouze condenser in the first instance, but not in the other.

TABLE I.—FIELD HOT TAR WASHING.

Washer without Pelouze Condenser.					
Temperature at inlet to washer	Tar content in grains per cu. ft.		Grains removed	Efficiency per cent.	Gas passed per 24 hrs. cubic feet.
	Inlet	Outlet			
31° F.	11.512	0.2930	11.219	97.46	2,463,000
27° F.	10.386	0.2160	10.170	97.92	2,453,832
29° F.	10.818	0.2930	10.525	97.29	2,341,800
29° F.	13.518	0.4170	13.101	96.92	2,397,000
26° F.	9.907	0.5250	9.382	94.70	2,400,000
Washer with Pelouze Condenser.					
30° F.	10.050	0.0436	10.0064	99.56	2,600,000
34° F.	13.100	0.0872	13.0128	99.34	2,600,000

The Feld process of tar washing was installed in a works in Bohemia in 1907, and the tar was fractionated into pitch, heavy oil, and light oil, with the result that the tar produced by the old method of condensation sold for \$5.00 per ton, while with the use of the Feld system producing the oils direct from the gas, the equivalent of this ton of tar sold for \$16.00.

#### NAPHTHALENE.

Naphthalene ( $C_{10}H_8$ ) is a hydrocarbon and has a melting point of  $174^{\circ} F.$ , a boiling point of  $424^{\circ} F.$ , and it sublimates at lower temperatures. The deposition of naphthalene in a solid state in the mains or apparatus causes many operating difficulties, as it decreases the cross-sectional area of the gas conduits and thus produces quite some back pressure on the works.

The presence of naphthalene in the gas is probably due to the high heats employed in present day carbonization, and it is presumed that these high heats cause a partial distillation of the tar with the consequent formation of naphthalene.

The greater portion of the naphthalene produced especially with high distillation or carbonization temperatures, goes over into the tar, the gas containing only a portion of the naphthalene vapor, its maximum content being dependent upon saturation at various temperatures, but outside of the temperature of carbonization the amount of naphthalene present in the gas is also due to the character of the coal used, and upon the time of contact between the gas and hot coke and hot retort walls.

The amount of naphthalene required to saturate a gas varies according to different investigators, none of them agreeing with each other.

In order to avoid stoppages in the pipe connections due to sublimation, it would be necessary to cool the gas as nearly as possible to a temperature corresponding to that of the gas in the buried mains, but as it is almost impossible to do this during cold weather, it becomes necessary to remove the naphthalene from the gas by means of a suitable extracting medium.

est solvents for this purpose are anthracene oil, creosote and water gas tar; the tar from vertical retorts has also been used for this purpose, but this tar must first be subjected to complete cooling.

All of the naphthalene should be removed from the gas, or the water would suffer considerably in candle-power, and no more should be expelled than what would produce sublimation without consequent stoppages.

Under ordinary conditions, 100 grains of anthracene oil will absorb from 10 to 25 grains of naphthalene, according to temperature, but before using this oil from 3 to 4 per cent. of phenols should be added, this addition leading to greater extraction efficiency, this efficiency being further increased by thoroughly and slowly cooling the gas, as the absorption is most complete at a temperature of from 60° to 70° F.

One per cent. of creosote oil will, under ordinary conditions, absorb one per cent. of naphthalene, by weight, but this absorption is dependent upon the amount of phenols present.

Water gas tar will absorb from 18 to 20 per cent. of its own weight in naphthalene, this absorption efficiency also being dependent upon the amount of phenols present.

Water gas tar, or if water gas oil, is used as the absorbing medium, it can be run back to storage bearing its naphthalene load, as the latter is not detrimental to the further use of the tar or oil, but if anthracene or creosote oil is used this can be regenerated for further use by being distilled and decanted, the naphthalene crystals being thus caused to crystallize out.

An attempt has lately been made to use naphthalene as a fuel in internal combustion engines, and some success has been achieved in this direction; the present drawback seems to be that it is necessary to start the engine with gas or some other fuel, and to so operate it until the heat generated by the gas is sufficient to melt the naphthalene, after which the naphthalene is fed to the engine, vaporized, and exploded. Complete

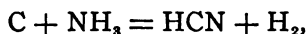


success in this direction would soon open up another source of revenue to the producer of coal gas.

It may be interesting to state that a locomotive operating on naphthalene has recently been constructed in France; this locomotive is provided with four cylinders, each two cast en-bloc, 5.5 inches bore by 8 inches stroke, 70 horse-power being developed at 950 revolutions per minute. This machine is provided with two carburetors, one used on starting with spirit, and the other for the naphthalene. The carburetor used in connection with the naphthalene is cast en-bloc with the reservoir in which the naphthalene is melted, double walls for the circulation of cooling water being provided, the temperature of this water being maintained at 212° F., thus maintaining a constant melting temperature.

#### CYANOGEN.

Cyanogen ( $C_2N_2$ ) is a gas composed of carbon and nitrogen, and it is probably produced during the period of carbonization in the form of hydrocyanic acid by the decomposition of some of the ammonia due to contact with the hot coke in the retort, as per the equation,



and the amount of cyanogen produced by the carbonization of any particular coal bears a certain relation to the amount of nitrogen contained in the coal.

The removal of cyanogen from coal gas is of decided advantage for two reasons, 1st, Owing to its corrosive effect on works apparatus, 2nd, Because it is a valuable by-product under certain conditions, also if cyanogen is permitted to pass on into the purifiers, it will be found to enter into combination with the iron in the purifying material, thus rendering a certain portion of this iron inactive for hydrogen sulphide extracton; on the other hand, the sale of spent oxide containing a high percentage of cyanogen is more remunerative than if it contained only sulphur, as this oxide is often purchased on the basis of its "prussian blue" contents only, "prussian blue" being the name applied to this cyanogen combination.

the revenue to be derived from the extraction of cyanogen from coal gas is dependent upon the amount of coal carbonized and upon the market price of the product, the latter fluctuating constantly; it is certainly not a remunerative proposition for works carbonizing less than 250 tons of coal per day, the same labor expended on a plant of this size, can readily be the proposition in one of double the capacity.

The estimated revenue in a plant carbonizing 250 tons of coal at one works, and 750 tons at another, the sludge from being worked up in one plant, after deducting operating expenses and 6 per cent. interest and 6 per cent. for depreciation amounts to \$27935.00 per year, and this, without the additional revenue, to be derived by the production of ammonium sulphate from the cyanogen press liquor, this liquor is sold on the basis of concentrated ammonia. Besides this revenue, the extraction of cyanogen in this case shows an increase of 22 per cent. in the action of the purifiers, or the life of the cyanide is increased by 22 per cent.

Of the two systems of cyanogen recovery which have met with the most pronounced success, is that of Bueb and the one introduced by Feld, the former making an insoluble ferro-cyanide and the latter a soluble cyanide sludge.

For a description covering the extraction of cyanogen by the Bueb process, attention is called to the paper read by Mr. Mueller during the 1910 meeting of the Institute, and which appeared in the PROCEEDINGS of that year.

The Feld process of cyanogen extraction differs from that of Bueb in that it is applied after the ammonia has been removed from the gas, this alkali being replaced with milk of lime in the copperas washing medium. The combined solution of lime and copperas is run into the Feld vertical washer, the resultant sludge coming from the bottom of the washer is boiled and then filter-pressed, the product coming from the filter press being calcium ferro-cyanide.

The product coming from either the Bueb or Feld plant, is then worked up into potassium ferro-cyanide, and in this



case the working up of the sludge produced by the Bu system requires additional apparatus for the removal and concentration of the ammonia carried in the sludge, while the working up of Feld sludge obviates the necessity of this ammonia apparatus, as the Feld system embraces the removal of cyanogen from the gas after the ammonia has been extracted.

#### AMMONIA.

Ammonia is a product derived from the destructive distillation of coal, and it results from the union of nitrogen with hydrogen, or  $N + H_3 = NH_3$ ; besides being an important source of revenue, the removal of ammonia from gas is necessary on account of its destructive influence on the brass and copper work of meters and gas fittings; when burned with gas it gives off noxious fumes of oxides of nitrogen.

The usual method employed for the removal of ammonia depends upon its solubility in water, and at ordinary temperatures water can absorb about 708 times its volume of ammonia gas, the absorption increasing with a decrease in water temperature, or

One volume of water at	32° F.	will absorb	1,050 volumes of $NH_3$		
"	"	50° F.	"	813	"
"	"	59° F.	"	727	"
"	"	68° F.	"	654	"
"	"	77° F.	"	586	"
"	"	183° F.	"	180	"

providing the pressure of the ammonia gas is equal to that of the atmosphere, and if the gas carries no tar burden.

The usual gas works method of operation, as practiced in America, removes the ammonia by condensation and washing; the first portion of the ammonia being removed in the hydraulic main due to the condensation of water vapors, which thus absorb ammonia. Cooling the gas in the condensers also causes the deposition of quite an amount of water which in turn absorbs more ammonia, the final ammonia being removed in the scrubbers or mechanical washers, using as little wash water as is consistent with the result desired, viz.: strong liquor.

Raw ammonia liquor from the plant usually contains from 1 to 2 per cent. of ammonia, and due to the cost of transportation, it would not, in most cases, be economical to sell this liquor in its diluted state; the raw liquor is, therefore, usually worked up for one of the following ammonia products:

1. Concentrated liquor.
2. Aqua ammonia,
3. Sulphate of ammonia;

but the product to be recommended for any particular gas works must necessarily depend upon local market conditions.

Concentrated ammonia is a product in which the raw liquor has been freed of a large portion of water, and it is used for producing other ammonia products.

Aqua ammonia is a solution of ammonia in distilled water, a great deal of it, in a dilute solution, being used for cleansing purposes.

Ammonium sulphate is produced by distilling the liquor, and absorbing in sulphuric acid; by passing the gas through an acid bath, thus absorbing the ammonia, or by combining the ammonia in the gas directly with the sulphur radical, discarding sulphuric acid.

The working up of the liquor is usually effected in continuous stills, Fig. 3, operating with a supply of live steam, and as the principle of design and operation is practically the same in the usual stills on the market, only one method will be described, the others differing only in detail, and not in principle.

The still usually consists of a series of superimposed sections, one mounted upon the other, constructed of cast iron, each section being provided with a steam passage in the bottom, covered with a hood or bell, and an internal overflow for liquor. These sections should be liberally provided with cleaning holes, by means of which access can be had to every part of the interior, so that the apparatus can be thoroughly cleaned without dismantling it. The liquor having been prev-

iously heated, enters at the top of the still and flows from section to section in a direction opposite to that of the steam

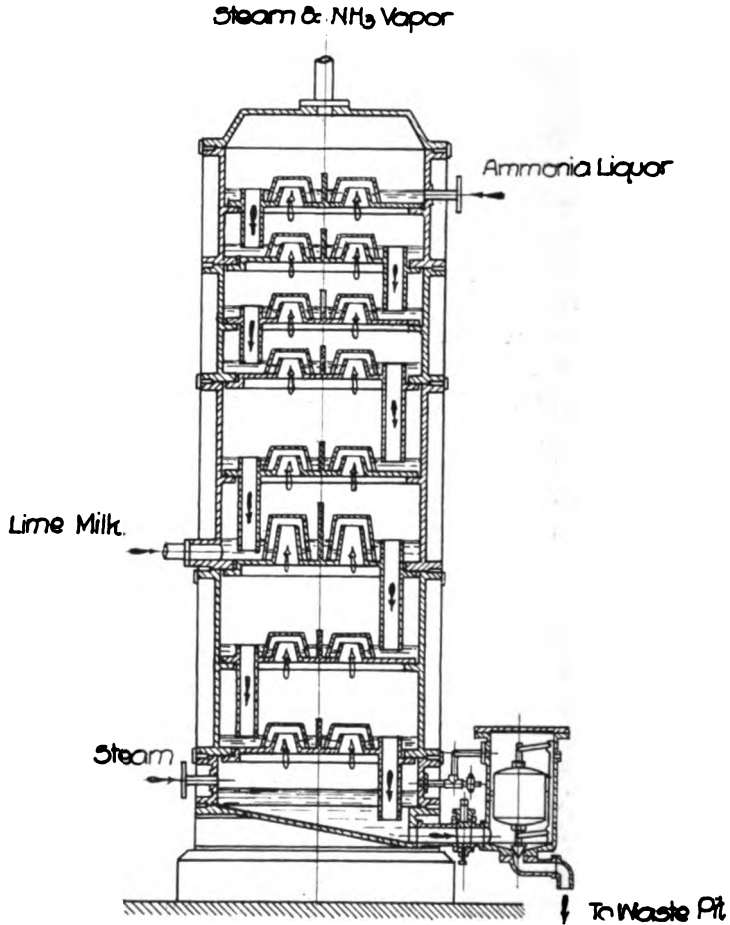


Fig. 3.—Ammonia still.

which enters at the bottom, passes up through the steam passages, and is caused to pass through the liquor by means of the hoods or bells.

The crude liquor is thus gradually brought to the boiling

the free ammonia and other gases mixing with the in the upper portion of the apparatus. The milk of introduced in small quantities into the lower, or liming, the hoods of these sections having a somewhat deeper than the others, in order to permit of more efficient mixing of lime and liquor. A final boiling of the liquor in the sections completely liberates all of the fixed ammonia, the stills should be so operated that the waste liquors from the bottom, should not contain more than 0.005 per cent of ammonia.

Concentrated liquor is to be produced, the vapors coming from the still are washed in a lime washer in order to prevent the formation of carbonate of ammonium, after which the vapors are condensed and run into storage.

The earning capacity of a concentrating plant operating in conjunction with a plant carbonizing 300 tons of coal per day, will be, with ammonia at eight cents per pound, about \$3.00 per year, or—

75,000 lbs. of ammonia at 8 cents.....	\$30,000.00
Labor .....	\$1,830.00
Materials .....	1,922.00
Miscellaneous .....	460.00
<hr/>	
Total operating cost, less interest and depreciation .....	4,212.00

Profit per year.....\$25,788.00

The weak liquor, as produced in the works, can be sold as is, and if the ammonia in this liquor, based on the above concentration of concentrate, is worth 6 cents a pound, the yearly revenue for this ammonia would be \$22,500.00, but from this would have to be deducted the added freight due to shipping in larger bulk, if the ammonia liquor is to be transported from the works, as well as pumping charges. In order to make the sale of weak liquor a profitable undertaking as compared with concentrate, it would be necessary that an ammonia works, which would take the entire output of liquor, be located in very close proximity to the gas works.

If aqua ammonia is to be produced, the vapors from the still are sent into lime washers, coolers, charcoal filters, oil washers, caustic soda washer, and finally into the absorbers.

The earning capacity of an aqua plant of the same size as that quoted above, should be about \$32,546.00 per year, or—

638 tons of 26° Bé. aqua at \$102.00.....	\$65,076.00
Labor .....	\$ 3,630.00
Materials .....	7,610.00
Miscellaneous .....	21,290.00
<hr/>	
Total operating cost, less interest and depreciation .....	32,530.00
<hr/>	
Profit per year .....	\$32,546.00

If sulphate is to be made from the ammonia vapors, these vapors are sent into the saturators containing sulphuric acid, where the ammonia and the acid combine to form sulphate, and the earning capacity of such a plant of the same size as those quoted above, should be about \$30,809.00 per year, or—

727 tons of sulphate at \$60.00.....	\$43,620.00
Labor .....	\$ 1,830.00
Material .....	10,221.00
Miscellaneous .....	760.00
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Total operating cost, less interest and depreciation .....	\$12,811.00
<hr/>	
Profit per year.....	\$30,809.00

The net earnings of these three plants is based on 250 maximum working days.

During the last fifteen years, the attention of investigators has been turned towards an endeavor to simplify the methods used to produce ammonium sulphate from the product due to coal distillation, and instead of treating the gas liquor itself, as in the old or indirect system just described, the endeavor has been to pass the gas directly into and through the saturator, which is a closed one in this case; this method of procedure has been termed the "direct process" and, as the name indicates, it is a reversal of the old method. Other investigators have

proceeded along somewhat different lines, and while passing the gas through the closed saturator, they, at the same time, vaporize the ammonia produced by previous condensation and then pass these vapors into the saturator in conjunction with the gas, this latter development being known as the "semi-direct" process.

The Feld system is even more truly a "direct process" than any of the methods mentioned above, as saturators containing sulphuric acid are not used; and when it is remembered that the production of one ton of sulphate requires approximately one ton of acid, the importance of this advanced step can be realized, Feld combining the sulphur in the gas with the ammonia thus producing ammonium sulphate by his polythionate process, no other oxydizing agent, except atmospheric oxygen, being required, and the latter is used only in the sulphur stove where the sulphur is burned to form sulphur dioxide, this sulphur stove thus displacing the sulphuric acid factory which has hitherto been a necessity.

The method of operation can best be understood by following the diagram, Fig. 4. The plant is started by filling the two regenerator tanks (B) and (C) as well as the wash liquor tank (D) with weak ammonia liquor from the works or with fresh water, this liquor or water being then pumped into the supply tank (U), from whence it flows into the top of the washer (A). Ammonia extraction immediately follows, and the liquor flows from the bottom of the washer as thio-sulphate, entering regenerator (B), where it is treated with sulphur dioxide coming from the sulphur stove (F), the sulphur dioxide being forced through the liquor due to pressure produced by the compressor (G). The overflow from regenerator (B) enters regenerator (C), where a further treatment with sulphur dioxide is effected, and then enters the wash liquor tank (D), from whence it is again pumped to the washer.

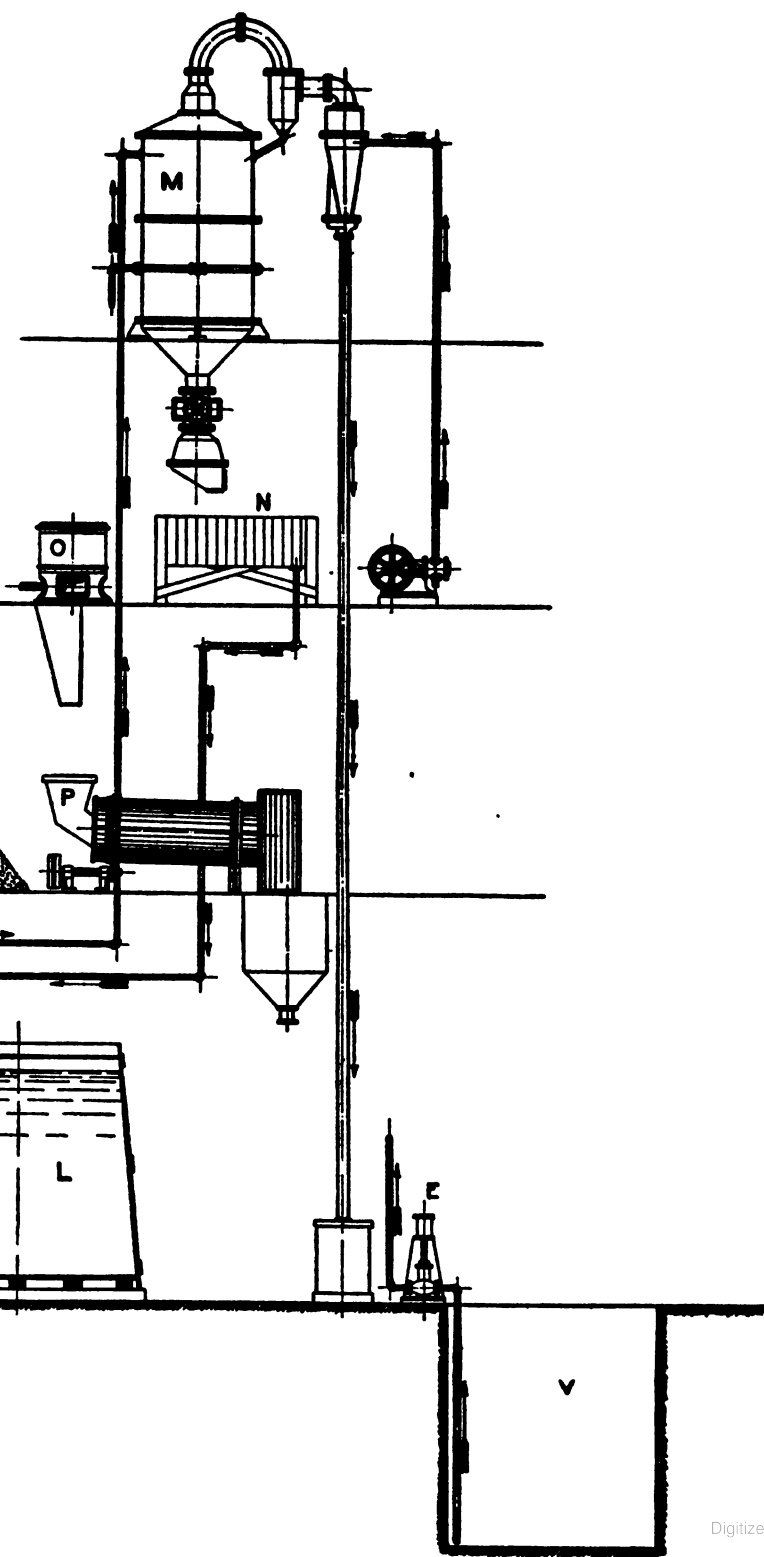
Alternately treating the liquor with sulphur dioxide and with crude gas forms polythionate in the first instance and thio-

sulphate in the second, the polythionate being the active washing medium; an equivalent amount of hydrogen sulphide is removed from the gas in conjunction with the ammonia in the washer.

When the liquor has obtained a strength equivalent to 35 or 40 per cent. of ammonium sulphate, a portion of this concentrated solution is pumped into the oxidation or finishing tank (H), it being replaced in the circulating system with weak liquor from prior condensation. In the finishing tank (H) the polythionate liquor is treated with heat through the medium of a steam coil, and some sulphur dioxide, if this should be necessary; by this treatment the thio-sulphates are transformed into polythionates which are in turn decomposed into sulphates and free sulphur.

The liquor, when decomposed, is drawn off from the finishing tank onto the sulphur drain board (J), and the free sulphur, which is in the form of hard grains, is placed in the centrifugal (K) where its moisture is expelled; this sulphur is returned to the sulphur stove (F) for the further production of sulphur dioxide.

The liquors from the drain board (J), as well as that from the centrifugal (K), flows to the precipitating tank (Q) where it is treated with some concentrated ammonia, or  $(\text{NH}_4)_2\text{S}$ , from the condenser (T); this liquor is then transferred to the storage tank (L) and is pumped from there to the vacuum boiler (M). The concentrated ammonia, or  $(\text{NH}_4)_2\text{S}$ , from the still and condenser is sent into the precipitating tank in order that any iron held in suspension may be thrown down, thus ensuring a clean, white salt; the amount of ammonia used for this purpose is very small, but it is all recovered in the sulphate. The liquor is evaporated in a vacuum (an open evaporator may be used if desired) in the boiler, and the salts are drawn out onto the drain board (N), and from thence to the centrifugal (O) and rotary dryer (P), the salts thus produced being ready for bagging and shipping. All mother







liquor from the drainboard and centrifugal returns to tank (L) and is from thence pumped back into the boiler.

The still (R) is used for the purpose of evaporating any ammonia liquor thrown down by previous condensation, these vapors being returned to the gas at the inlet to the washer, a small portion of the vapor being sent into the condenser (T) for producing the  $(\text{NH}_4)_2\text{S}$  used in the precipitating tank. The use of a still is dependent upon the method of operation; if Feld's system of hot tar extraction is installed a still will not be necessary, as there will be no precipitation of ammonia under these conditions; a still is also not necessary if the production of ammonia liquor does not exceed the amount of liquor required in circulation.

This process requires but very little expert control, the usual mechanics attending the machinery being capable of making the necessary liquor tests after some little instruction.

The Bueb process for the extraction of cyanogen produces ammonium sulphate in solution, and therefore, this process, in combination with the Feld explained above, forms a very remunerative proposition.

The income from such a combined plant in a works carbonizing 300 tons of coal per day is approximately as follows, based on 250 maximum days per year:

Cyanogen .....	128,500 lbs. at 13.25c.....	\$17,025.00
Sulphate .....	1,349,250 lbs. at 3.00c.....	40,477.50
NH <sub>3</sub> in press cake .....	29,750 lbs. at 7.00c.....	2,082.50

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Total gross earnings .....\$59,585.00

The operating expenses are:

Materials .....	\$3,695.00
Steam .....	1,663.00
Power .....	2,688.00
Miscellaneous .....	1,000.00
Labor .....	2,500.00

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Total operating expense ..... 11,546.00

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Net earnings per year less interest  
and depreciation .....\$48,039.00

## BENZOL.

While the removal of benzol from gas is not of remunerative interest to the coal gas producer under the present antiquated standard of gas sale by candle-power, it is of special interest to the by-product coke oven operator, and as all of the preceding data applies to both of these producers, the method of removing and purifying benzol, is herewith included.

Benzol is recovered from coal gas after the tar and ammonia have been removed, and all modern systems are based on the original process as carried out by Brunck in Germany in 1887. The gas is washed in a series of washers with light oil, this oil absorbing the benzol, after which the raw product is subjected to a number of distillations, producing benzol, toluol, xylol and solvent naphtha.

The Koppers Company states that the income due to the extraction of benzol from the gas produced by the carbonization of 2,000 net tons of dry coal per day, is as follows:

*Yearly Recovery.*

Benzol, 67 per cent. ....	978,000 gallons
Toluol, 16 per cent. ....	234,000 gallons
Xylol, 8 per cent. ....	117,000 gallons
Solvent naphtha, 9 per cent. ....	131,000 gallons
<hr/>	
Total .....	1,460,000 gallons

## With a gross income of—

1,460,000 gallons at 15 cents .....	\$219,000.00
Crude naphthalene, 330 net tons at \$5.00 .....	1,650.00
Regenerated acid of 40° Bé., 360 net tons at \$6.00 .....	2,160.00
<hr/>	
Total gross income .....	\$222,810.00

The operating expense per year being—

Raw material, consisting of wash oil, sulphuric acid, caustic soda .....	\$15,000.00
Steam for distillation, air compressor, loading pumps, acid regeneration and cooling water .....	15,000.00
Electric power for water pumps, oil pumps, agitator, illumination .....	6,200.00
Wages for three distillers and two helpers.....	5,000.00
Overhead expenses, fire insurance, maintenance and depreciation, assuming the cost of the complete plant to be about \$300,000.00.....	30,000.00
Calorific loss of the gas.....	13,000.00

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Total operating expense ..... '\$84,200.00

giving a net profit of \$222,810.00 — \$84,200.00 = \$138,610.00 or 46 per cent. on the investment capital, and making the cost of producing one gallon

$$\frac{\$84,200.00}{1,460,000} = 5.8 \text{ cents.}$$

This profit is of course dependent upon the selling price of benzol and the cost of raw material.

(Mr. Wagner read an abstract of his paper.)

MR. V. VON STARZENSKI (Schenectady, N. Y.): I want to ask my friend Mr. Wagner a question that I hope will not seem pointed, and that is, how many sleepless nights did he spend trying to work in another washer so that he could sell them by the dozen. In his paper it is not quite clear to me how he fractionates tar. You have first four washers, practically one machine, that is, as far as pumping is concerned. You pump light oil into the third washer to wash out the heavier or middle oils; you pump the middle oil into the second washer to wash out the heavy oils, and then the heavy oils to wash out the pitch. As they wash one into the other, how do they separate out?

MR. A. B. WAY (Everett, Mass.): I want to ask Mr. Wagner, first, whether there is not considerable condensation of heavy tar and pitch in the collecting main at temperatures in

excess of those quoted for the operation of the first washer. Such being the case, which would be the better procedure—to have a separate tank for this condensation, or run it into the tank with the tar from the first washer?

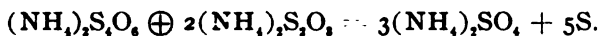
In the explanation of the operation of a hot tar washer, it is not quite clear just where the wash tar comes from. On page 343, the author says that heavy oils from the second washer are pumped into the first washer, but in the drawing and explanation thereof he shows that a mixture of hot wash tar and extracted tar flow into the hot tar tank at the bottom, and are repumped into the same washer, except for the excess, which overflows to the tar storage. As there would always be, therefore, sufficient tar in the wash tar tank to supply the washer, where are the heavy oils introduced, and what governs such choice of place?

On page 358, Mr. Wagner speaks of the separation of the sulphur in the oxidation tank as being in the form of hard grains. Of course the natural physical form of separated sulphur is that of a material in a very fine state of division, so fine that it will pass through the finest filter paper. It is possible by continued boiling to coagulate these particles somewhat, or by raising the boiling point by the addition of a salt, one may get the sulphur in granular form. And I would therefore like to ask Mr. Wagner, to what temperature this tank is heated? With ammonium salts present to the extent of the equivalent of 35 or 40 per cent. ammonium sulphate, the boiling point may be sufficiently high to granulate the sulphur. Is that the secret of the hard grains?

In this same connection, Mr. Wagner speaks of treating the liquor in the finishing tank with some sulphur dioxide, "if this should be necessary." Is it not absolutely necessary to do this? As he has explained, the liquor comes from the washer in the form of thiosulphate, which latter will not decompose into sulphate, but rather into sulphite and free sulphur.

By conversion to polythionates, however, with the aid of sulphur dioxide decomposition to sulphate is easily effected.

In fact, with only partial conversion in polythionates, this may be effected, for one molecule of polythionate and two of thiosulphate will react to form sulphate and free sulphur.



But on the other hand, would it not be quite possible that without the sulphur dioxide treatment there might be insufficient polythionates present to complete this reaction so that the final product would contain thiosulphate, which in time would decompose into sulphite and free sulphur?

It seems to me that the precipitation tank is a commendable feature, not only to rid the solution of any iron which on subsequent oxidation would give a color to the salt, but because one might expect to find in the unfinished solution rather more than traces of thiocyanates. If the thiocyanate of iron solution were to be evaporated with the rest, it would impart a red color to the salt, but with the iron removed, the ammonium thiocyanate would be broken up in the vacuum boiler and the disturbing member removed with the steam.

In connection with this, there is another point which is not quite clear. In order to precipitate the iron, ammonia must be added in excess, and I presume that this iron is removed either by settling and decantation of the supernatant liquid, or by filtration. Whichever way it is done, there must be free ammonia present in the solution, and when the latter is put through the vacuum boiler, what is there to prevent this free ammonia from escaping? How is it all recovered in the sulphate?

MR. C. J. RAMSBURG (Chicago): I should like to ask Mr. Wagner whether there is one of these plants in operation? If so, is it connected with a gas plant, or coke oven? It seems to me there would be considerable deposition in the mains, even when lagged thoroughly, on account of the high temperature condensates present, particularly in coal gas from retort plants.

Reference is made on page 348 as follows:

"The Feld process of tar washing was installed in a works

in Bohemia in 1907, and the tar was fractionated into pitch, heavy oil, and light oil, with the result that the tar produced by the old method of condensation sold for \$5.00 per ton, while with the use of the Feld system producing the oils direct from the gas, the equivalent of this ton of tar sold for \$16.00."

I think it misleading to say that by using the Feld system, they were able to get \$11.00 per ton more for the tar, when as a matter of fact, I think what should be said is that by separating the tar in various fractions, he was able to get \$11.00 more per ton. Of course, what is done in this separation by Feld's system, can be also done by distilling the tar after it has been taken out in the ordinary manner. It also seems to me highly improbable that the products from this system could be disposed of to advantage. Having been separated in a manner such as this, it would be hard to find a purchaser for these various products, which would have particular characteristics. The pitch, for example, would be a pitch of a definite quality and melting point. It would not be a pitch which could be made to sell to meet a certain specification of melting point. So, while it seems to me that if practical and workable, there could be considerable in this type of plant, yet it would necessitate large investment, and I believe the same end could be accomplished by condensing the tar out and distilling it to much better purpose.

MR. W. H. FULWEILER, (Philadelphia): I do not know whether it is a typographical error or not, but on page 349 it says: "Water gas tar will absorb from 18 to 20 per cent. of its own weight in naphthalene, this absorption efficiency also being dependent upon the amount of phenols present." It is my understanding of water gas tar that there is no phenol present. I just wondered what Mr. Wagner really meant to say.

MR. W. J. MCGURTY (New York): With regard to the condensation in the main, which has been referred to, I wish to say that while there are no plants of this type in operation here, there is one working at Ilseder near Frankfurt, in which the main has been lagged, and any condensate produced at this

point is mixed with the washing tar, the separation subsequently taking place in the washer.

With regard to the value of the fractionated products compared with the original tar, the paper mentions that the "equivalent" of a ton of tar produced in this process sold for \$16.00, instead of the total tar selling at this price, the increased value being due to the fractionation.

I am very sorry I did not catch quite all of Mr. Way's criticism regarding the chemical feature of the process. As the operation has been both experimented with, and investigated under, working conditions, I feel that the criticism would not have been made if the chemical control of the process had been more closely investigated.

As regards Mr. Fulweiler's statement, referring to the extraction value of water gas tar for naphthalene, the figures quoted have been obtained in practice.

MR. FULWEILER: You misunderstood my question. I did not question the statement that water gas tar would absorb that much naphthalene. You spoke of its value as an extraction agent due to the presence of phenol. Phenol does not exist in water gas tar.

THE CHAIRMAN: Mr. Wyant, have you anything to add to this?

MR. WYANT: It seems to me it would be well to emphasize still further the fact that the figures given on pages 355 and 356 regarding the ammonia returns are not relative figures. It is quite evident that these figures are not based upon the same quantity of coal carbonized, and while they are definite figures, it might appear that there was a definite relation between these returns and the definite quantity of coal stated. In the case of the concentrating plant, the ammonia indicated amounts to the sale of 3.4 lb. per ton, while in the case of the aqua plant, assuming the same quantity of coal carbonized, the returns indicated equal 4.28 lb. per ton, and in the sulphate plant equal only 3.3 lb. If we assume that these figures are relatively correct for the same quantity



of coal carbonized, we might infer that aqua yields the maximum return, which is not necessarily true. I think it is important to notice that the interest and depreciation charges are omitted from the costs charged against the returns. I note, too, that the returns are based upon the selling price of gas at \$102.00 per ton. This is a higher price than I believe aqua ammonia is selling for at the present time, at least in the East. Then, too, if we deduct from the net returns the necessary capital charges for the different products, we should have a leveling in the returns, which is not indicated in the paper.

MR. M. E. MUELLER (Astoria, Long Island, N. Y.): I should like to ask Mr. Wagner whether, to make the diagram of the washers on page 342 complete, there should not be a condenser shown between the adjoining washers?

THE CHAIRMAN: Now, Mr. Wagner, will you close the discussion?

MR. WAGNER: In regard to the removal of the various fractions which have been questioned, I would state that in order properly to explain that, the entire theory of condensation as outlined by Dr. Feld would have to be placed before you, but it is all based on treating the gas at the dew-point for the various constituents which are to be removed, and no positive temperature can be given for any series of gases. That dew-point must be established in each individual case. Of course, slight variations plus or minus are allowed, but I cannot tell you that it requires a temperature of 160 degrees, or 100 or 120, or any other degree to accomplish a certain purpose. That temperature must be established in each individual works. Referring to the question of hard grains of sulphur and the temperature at which the finishing or boiling tank is operated, I would state that this is at 212 degrees. When I say hard grains of sulphur, I mean grains of sufficient density and size so that they can be removed in a hydro extractor. The use of some additional sulphur dioxide gas in the finishing tank is not at all necessary, provided the operator of the plant has attended to his business. If he has not done so,

and he does not get polythionate liquors into his finishing tank, he will have to give it sulphur dioxide gas in order to convert the thiosulphate into polythionate. The plant must, however, be so arranged that you have to depend upon the human element, and if the operator does not treat his liquor until he has polythionates, he will not produce ammonium sulphate. Then you must give him an opportunity to add the necessary sulphur dioxide to the thiosulphate in order to produce the polythionate. Then by heating it to about 212 degrees, his polythionate is broken down into ammonium sulphate and free sulphur.

Referring to the diagram on page 342, it will be seen that you never pump the same material into the washer from which it came. You are pumping the material from a succeeding washer into a preceding one. I think that is all.

THE CHAIRMAN: The Chair will entertain a motion for the thanks of the meeting to Mr. Wagner.

A motion to that effect was made, seconded and carried.

THE CHAIRMAN: The next business on the program is a symposium, "Operating Experiences Under a Calorific Standard." Will Mr. G. H. Waring, of Charleston, S. C., open the discussion?

## OPERATING EXPERIENCES UNDER A CALORIFIC STANDARD.

(SYMPOSIUM.)

MR. WARING: I don't know just exactly what was intended to be brought out in this discussion. We are not operating on a purely calorific standard in Charleston. We are operating on a dual standard, that is, candle-power and calorific value. Our standard is 600 B. t. u. gross and 20 candle-power water gas. Our experience has been that by obtaining the necessary 600 B. t. u., we haven't any trouble in getting the 20 candle-power; in fact, our average for a year taken at the plant gave us 21.18 candle-power with 604 B. t. u. I imagine the object of this discussion was to bring out the fact,

whether any particular difficulties were found in operating on a B. t. u. standard. My experience has been that it is much easier to operate a water gas plant on a calorific standard than it is for candle-power. The temperature changes have less effect on calorific value; in other words, the calorific value might be said to be dependent on the amount of oil you use, whereas the candle-power is dependent upon how you work your oil up. If you crack your oil up and get it into the gas, you get the B. t. u. It is not so with the candle-power, but it is, from the operator's standpoint, very much easier to operate under a calorific standard than it is by candle-power standard. From the point of view of the consumer, undoubtedly all he wants is the calorific value. Under the present method of using gas, there is no necessity for the candle-power. I should like to say that our calorific standard is rather high. We are required by the municipality to give 600 B. t. u., which we consider rather exacting.

MR. G. T. MACBETH (Mount Vernon, N. Y.): Mr President, we have never operated on a calorific standard. We have operated on a candle-power standard, and observed the B. t. u. There seems to be a point referred to, which Mr. Waring brought to my mind, and that is this: In general you can operate with less than 600 B. t. u. and maintain 20 candle-power, if you are allowed to use a Sugg F Argand as test burner. Mr. Waring, I understand, is not allowed to use this burner. I don't believe the Sugg F Argand burner is allowed in any except third class cities and villages in New York State. Second class cities and first class cities require No. 7 Bray.

MR. D. MACARTHUR (St. Louis): I would like to state that in St. Louis we have been operating under both a candle-power and a B. t. u. standard for the past 10 years, and we have been able to watch the B. t. u. very closely. While the city requirements for candle-power are 18 candle-power anywhere around town, we have also maintained in addition, 600 B. t. u. gross anywhere. This latter stipulation fixes the

general quality of the gas, so that we never need to pay much attention to the candle-power, but do pay particular attention to the B. t. u.

In the manufacture of coal gas, we have found that in order to get a reasonably fair quality of gas, we must watch the seals and the way the gas is treated, and in general we have no difficulty whatever in keeping our B. t. u. well over 600, and at the same time press our yield up close to 6 ft. The matter of regulation in a coal gas plant and the care of the hydraulic main have an enormous amount to do with the keeping up of the B. t. u. If the main is allowed to become uneven, if the dip pipes are not checked up for level, and if the seal is not properly set, there is either a large leak of gas in various places or else the B. t. u. drop, due to the introduction of extraneous gases. The care that we give to our water gas is much the same. We check the oil every hour and observe the B. t. u. every half-hour; we also watch the heats, pressure, generator fire and treatment, so that we know at all times just what is going on at the plant. We have a relief holder that holds approximately 150,000 cubic feet at one plant, and another that holds 300,000 cubic feet at the second plant. The advantages, of course, in having a large relief holder are that you can get a good mixture of gas and so maintain the B. t. u. evenly, and also that the pumping of water gas can be carried on more evenly through tar extractors and purifiers.

The big disadvantage is that should you be making poor gas and get a holder full of poor gas, you are in hard straits, so that then a small holder would be preferable.

One of the things that we have encountered in recent years has been to keep the B. t. u. at such an even range that there will be no difficulty whatever in using it in the different gas arcs that are on the market and in the different devices in use for industrial purposes. At one of the stations that happened to be equipped with an old holder with but two main connections on it, the difficulty we experienced there was that

with gas being pumped for the high pressure system, and with low pressure gas going out of the holder, and with gas going into the holder all at one time, it made it almost necessary to have three mains, but inasmuch as it was the only holder at the station, we could not very well change it. Should we take the gas used for both high and low pressure distribution, from the outlet, the pulsations of the blowers would seriously affect the low pressure around town by causing the lights to flicker; on the other hand, if we took the gas for the high pressure blowers, from the inlet of the holder, we did not get a good mixture, and this was important, as the high pressure system, besides supplying outlying holders, fed low pressure mains. In order to maintain an even range of B. t. u., we adopted the system of having all the gas go into the holder and taking it out with high pressure blowers, and then by a fixed connection from the high pressure line to the low pressure line, supply the low pressure distribution from the station.

MR. ROLLIN NORRIS (Philadelphia): I rather hesitate to discuss this question of experience in maintaining a calorific standard, but I thought it might be of interest to say this, that all of the works connected with The United Gas Improvement Company are now operating on a calorific standard exclusively, except in cases where our franchise requires either the dual standard or a candle-power standard. We have not been at it long enough to know just exactly what it means, but we do know that we can maintain, on monthly averages, very close accord with a predetermined standard.

Speaking generally, the heat conditions of fixing vessels that give the highest candle-power, give the highest heating value per gallon of oil used. Where the conditions require you to maintain a monthly standard, you come very close to it, but there should be a considerable variation allowed in the daily standard, because so far it is as impossible to maintain an absolutely uniform heating value as it was to maintain an absolutely uniform candle-power, but I believe that our public now are getting a more uniform quality of gas, a more satis-

factory uniformity in quality under the present method of operating than they were under the strictly candle-power standard.

MR. E. C. JONES (San Francisco): What I have in mind to say about candle-power and heating value will be more or less foreign to eastern conditions. In California, as you all know, we are manufacturing gas exclusively from crude oil and its distillates, but the gas after it is made is so nearly like coal gas that it is impossible to detect the difference by analysis in the laboratory excepting that the hydrocarbons known as illuminants exist in larger percentage. In San Francisco, we are unfortunately required to supply candle-power as well as 600 B. t. u. per cubic foot. Other California towns are doing away with the candle-power requirement, giving the gas maker the opportunity to avail himself of some of the advantages accruing to the making of oil gas without high candle-power. There is a peculiarity about our oil gas. On account of its comparatively low specific gravity, it has a large flame area, and therefore a large area for the diffusion of light; so a 16 candle-power oil gas visually gives almost as good results as a 20 candle-power water gas. In the manufacture of oil gas, in the beginning we used about 13 gallons of oil to 1,000 cubic feet, and by improvement this has been reduced to about  $7\frac{1}{2}$  gallons per 1,000 cubic feet. In the careless breaking up of oil—and this might also be applied to the manufacture of water gas as well—in the overheating and underheating, that is, zone heating of oil and the destruction of it by overheating, the carbon and hydrogen are torn apart and the result in oil gas manufacture is the production of a large quantity of what we call lamp black as a residual. In the beginning of the oil gas business, we produced as much as 50 lbs. per 1,000 cu. ft. of lamp black. It is almost pure carbon. It runs about 98.6 per cent. carbon, and is a valuable fuel for boiler firing, and is being briquetted and sold for domestic fuel. We have taken out of our gas (in the manufacture of lamp black) stable hydrocarbons, light giving

and heat giving, and we have remaining, hydrogen, a very much overrated gas. It is very hot by the pound but very light, and we have sacrificed valuable hydrocarbons to get it. This also happens in the manufacture of water gas. We sacrificed hydrocarbons, of from 2,000 to 4,000 B. t. u. per cubic foot and have on our hands lamp black residual, and hydrogen with only 344 B. t. u. per cubic foot; and if the process were to be continued in the way we began, we would find it impossible to make oil gas containing as much as 500 or 550 B. t. u. But by using care in the application of heat to oil, we have succeeded in reducing the lamp black residual to less than 5 lbs. per 1,000 cu. ft. We have improved the quality of the gas and reduced the quantity of oil. In regard to the heating value and candle-power, I have heard so much said about the relationship of the two, but I have failed entirely to find any relationship between candle-power and heating value. When I was associated for a while with Prof. T. S. C. Lowe (San Francisco) trying some experiments in the manufacture of coke oven gas, we succeeded in making a non-luminous coal gas of 750 B. t. u. It seemed to me that it exploded the idea of any relation between candle-power and heat units, and I always deplore the fact when I go into some laboratories and actually find charts with candle-power and heat units classified as though one had a relationship to the other, that is, with so many heat units per cubic foot, gas must be of a certain candle-power, and vice versa. I find that there is no relation between them. Accidentally, it may happen once in a while.

Speaking of calorimeters, I believe the calorimeter that will be most satisfactory will be the bomb calorimeter for the actual burning of gas with oxygen, whereby all of the heat of combustion is absorbed. It seems to me that any calorimeter of the Junker type, that is dependent upon a burner for consuming the gas, must be very faulty. I have been much disappointed in the use of the Junker type of calorimeter in making calorimetrical tests of different hydro-

in gases, acetylene, for instance, where the Junker calorimeter, which gives fairly good results with standard gas, is here from 25 to 40 per cent. out of the way. I have found, that the best calorimeter in the world is the ordinary kitchen clock, costing about \$1.00. If you put the 'kitchen clock' on the mantle piece in the kitchen, where a gas stove is used, you will find that any variation in heat units in the gas will make a vast difference in the number of minutes which are required to finish the roasting of meat, and if John has supper at 6 o'clock at night and the gas has not the heat in it, the kitchen clock tells the story, because the roast is not done until 6.30. A few heat units difference are magnified into many minutes. You will find it is a very sensitive calorimeter. I thank you, gentlemen. (Applause.)

MR. J. M. MOREHEAD (Chicago): In Illinois, after January 1, there will be no candle-power requirements, but instead, a calorific value of 565 B. t. u. This ruling of the Gas Commission will enable gas to be made out of Illinois. Chicago has, however, been made an exception to the rule, and is still under its candle-power standard, to maintain which, although the heat units do not go up and down with the candle-power, it has always been necessary to furnish more than 565 B. t. u.

The question has come up as to just what the relationships are between B. t. u. and candle-power are, and we agree with Mr. Morehead in saying that they are like the snakes in Ireland—there are no snakes in Ireland. In the last 20 years we have been making gas with the candle-power in view entirely, with no reference to the heat units. If we stop paying attention to the candle-power and give all our attention to the calorific value of the gas, I think we will be able to get more of heat units out of a gallon of oil than we are doing now. The calorific value up to this time has been something that we paid no attention to, because we did not have to. For a long time, we did not know what it was except in a general way.

We have been taking the calorific value regularly in



Chicago for only four or five years, though we have been taking candle-power ever since the fire.

MR. WARING: While there is no relation between the candle-power and heating value of water gas, there is a relation between the heating value and the candle-power per gallon of oil used. A chart has been designed with three elements: Candle-power, candles per gallon, and heating value. This chart was based on the operation of several plants. By its use, knowing the candle-power and the candles per gallon, we could get from the chart a heating value which checked very closely to the actual value found by calorimetric tests, as shown by these results for the year 1913:

	Heating value	
	Chart	Actual
January .....	596	612
February .....	600	606
March .....	594	607
April .....	582	607
May .....	594	600
June .....	599	600
July .....	588	600
August .....	594	599
September .....	590	603
October .....	596	603
November .....	608	602
December .....	594	603
Year .....	594	604.5

The advantage of the curve shown by the chart is that we can take the candle-power hourly as we go along, and knowing the general conditions of the amount of oil we are using, the candle-power we are getting, we can assume approximately the candles per gallon, so that from the chart we can tell at once very close to our heating value, and do not need to make a calorific determination but once a day.

MR. NORRIS: In my experience with water gas, within ordinary practical limits, a gas of a given candle-power will vary in heating value according to the amount of oil used per M for producing that candle-power, that is, the lower the oil

per M, the lower the heating value. For gas of a given candle-power and with a given candle-power efficiency per gallon of oil used, the heating value will be shown very closely by the chart devised by Mr. Klumpp, and which was, I think, published in connection with some of the committee reports of the Institute. The chart gives quite close results over a considerable range of candle-power and a considerable range of oil efficiency, and, as a practical working device, is very useful.

MR. C. C. TUTWILER (Philadelphia): I would like to ask Mr. Waring or Mr. Norris whether it is not necessary that the gas be tested under absolutely uniform conditions in order that Mr. Waring's statement holds good. By uniform conditions, I mean through a 70-degree coil. I think there is no doubt that the rule will hold good under such standard conditions of test, but I do not think it will hold good after the gas has been subjected to varying pressure and temperature conditions in the holders and distribution mains.

MR. C. J. RAMSBURG (Chicago): It seems to me that this curve is based on the assumption that the B. t. u. per candle vary directly with the candle-power per gallon. This assumption is true only when measured at the inlet of the holder; it is not true when measured a mile from the works in June and again in February. In water gas, you get about 28 B. t. u. per candle. If you take the benzol out of this, the factor will change strongly.

DR. A. C. HUMPHREYS (New York): Having keenly in mind that our work is interpreted for us by Public Service Commissions and others, may I ask if, in these calculations, it has been discovered that there is an absolute candle-power, in candles per feet? I think it would be very unfortunate if it got on our records, to give the impression to those who are telling us how to work, that there is a definite relationship between candle-power and B. t. u., whether it is coal gas or water gas or any other kind of gas.

THE CHAIRMAN: To whom is your question addressed, Dr. Humphreys?

DR. HUMPHREYS: I am not asking a question, I am stating facts, that is all. Mr. Waring can answer, if he likes.

MR. WARING: In answer to that question, I positively stated that there was no relation between candle-power and heating value.

DR. HUMPHREYS: I have now just what I want, because, unquestionably, without some such definite statement, having in mind my experience with a certain kind of expert and those who listen to this kind, it might be possible to present a plausible argument, based upon that discussion, in support of the proposition that there is such a relation. There has already been a good deal said about candle-power and candle-feet that might be taken to indicate that these are positive values, without regard to how these values were obtained.

MR. A. M. BARNES (Cambridge, Mass.): There is one feature of this discussion as to the relation of candle-power and B. t. u., or heating value, that has not been touched upon. and it seems to me it is a very important one. I think we are all agreed that the heating value is the more important question to be considered in determining the basis on which gas should be manufactured and sold, and it seems to me to be a generally accepted belief that the gas manufacturer or gas engineer can work more easily by the B. t. u. standard than he can by a candle-power standard, but the pecuniary results do not seem to have been touched upon at all. What, if any, appreciable difference can a gas engineer get in the cost of gas if he works for calorific value rather than illuminating value?

MR. MOREHEAD: Some years ago we ran some tests in Chicago to determine the effect of oil on the blue water gas. We started and ran from  $\frac{1}{2}$  gallon to the 1,000 up to 7 gallons to the 1,000. As is well known to all water gas men. you do not get any candle-power up to 2 or  $2\frac{1}{2}$  gallons per 1,000. The gas burns clear until about 2 or  $2\frac{1}{2}$  gallons, then

begin to get a fringe around the blue flame. An analysis of the gas would show the oil, and the calorimeter would show that as to the candle-power, the photometer would not show it. After about  $2\frac{1}{2}$  to 3 gallons, the candle-power would increase very readily with the oil, until you would get up to a point where you would get something like 28 to 30 candles, and then the further addition of oil does not help it much, and the candle-power all drops out again. Now, I did not hear Mr. Warren—I was upstairs—but I agree with him that for the same amount of gas made under the same conditions, and through the same flow ranges, there is a certain sort of relationship, but if you get more than 3 or 4 candles above or below, your relationship does not hold any longer; if you have 5 gallons of oil and 24 candles, and you cut 3 gallons out, you do not have any light at all, and according to his chart, you ought not to have any heat units at all, giving you something that would not hold, which we know is not the case. This is all with reference to water gas. At one time we had quite an excess of natural gas in Chicago. We found that we could raise the candle-power in water gas with natural gas without raising the candle-power hardly at all. You can raise the candle-power by the use of benzol, or by the use of acetylene, with scarcely any increase in the heating value. Natural gas has 1,000 heat units in it, with practically no candle-power. Acetylene has 240 candle-power and only 400 heat units per foot more than natural gas. You can increase the one without increasing the other. My contention was, that the two factors you get from candle-power and B. t. u. are utterly dissimilar and they do not go together. If you increase one, you do not necessarily increase the other—you may increase it, but not in any fixed relation, nor is there any fixed relation between B. t. u. and oil per 1,000. You can put in so much oil, or good gas, or get your machine so hot that you will practically burn it all up and you do not get any candle-power, but you do get a certain increase in your heat units. Within a narrow range, with the same kind of gas, he is right, but

to say that 18 candle-power gas in water gas has certain heat units, and then to say that the same candle-power in coal gas or acetylene, or a natural gas enriched with benzol to candles, would all have the same amount of heat units, is not borne out by the facts at all. We have experimented with a number of these mixtures in Chicago; we have carried it all through trying to substitute acetylene for oil.

MR. JONES: I should like to call attention to a phenomenon I noticed recently, that is, if you mix a non-luminous natural gas, 40 or 50 per cent. in volume, with a 13 candle-power oil gas, you raise the candle-power of the gas to about 18 candles due to raising the flame temperature and increasing the incandescence of the hydrocarbons of the 13 candle-power gas. It is something worth thinking over.

THE CHAIRMAN: Unless there is some other member who wishes to speak on this question, we will pass to the next business.

#### REPORT OF THE SECTIONAL NOMINATING COMMITTEE.

THE CHAIRMAN: The Sectional Nominating Committee has requested that its report be submitted to-day. If there is no objection, the report will be received at the present time.

MR. W. CULLEN MORRIS (New York): The Committee has nominated, according to the provisions of the Constitution, three names. They are: Mr. E. H. Earnshaw, of Newark, Mr. G. E. Woods, of New York, and Mr. R. B. Brown, of Milwaukee. (Applause.)

MR. A. S. MILLER (New York): I move that the Secretary cast one ballot for these men.

There were several seconds to the motion.

THE CHAIRMAN: That the Secretary be instructed to cast one ballot for this section for the nomination of these three members, from whom the candidate for Vice-President will later be selected by the Nominating Committee of the Institute. All those in favor will please say aye. (Ayes.) Those

ed, no . (No response.) Will you cast the ballot, Mr. Secretary?

The Secretary stated that he so cast the ballot.

THE CHAIRMAN: I announce that the Secretary has cast the ballot as directed by the Section, and that the gentlemen nominated have now been nominated as candidates.

The next business is the paper "Efficiency Relation Existing between Various Argand and Open Flame Test Burners," by J. Gilpin, of Philadelphia.

## EFFICIENCY RELATION EXISTING BETWEEN VARIOUS ARGAND AND OPEN FLAME TEST BURNERS.

### (A) INTRODUCTION.

With the increased development and use of heating, fuel industrial appliances and incandescent burners, the demand for a uniform heating value of a gas has been brought to such prominence, that strict rules and regulations have been laid down to ensure its accurate determination by instruments scientifically designed for the purpose. Each step of the process has been separately investigated and limits established for its proper conduction. This can readily be seen by reference, especially to the reports of this Institute's Committee on Calorimetry.

On the other hand, efforts to establish a uniform method of determining candle-power have been more or less desultory and spasmodic. To be sure, much effort has been expended in establishing methods of maintaining a uniform candle-power and delivering a gas of uniform candle-power to the uttermost consumer who is still existing by the light of an open flame burner. But as long as it will be found necessary to state on what type of burner candle-power determinations are made, the method of taking candle-power cannot be considered as a process scientifically accurate for comparison of results obtained under different conditions.

of manufacture, or a true measure of the photogenic property of the gas.

While, for calorific determinations, instruments are used that will give the nearest approach to the actual heating power of the gas, candle-power determinations are usually made on types of *commercial* burners that fail to do the same for the light-giving power. In fact it is at times specified that the test burner shall be one available to the consumer, with the result that the manufacturer of gas in one locality is placed at a greater disadvantage than in another, due to the type of test burner selected. Some effort has been made to determine the exact relation between candle-power and heating value, but with indifferent results. For gases manufactured from different fuels and by different processes, this value has a widely varying equivalent that leads to no certain result, though under certain fixed conditions and within narrow limits, the variation of the two properties has a more definite relation.

With the increase of purchase by specification, and of regulation by commission, it becomes increasingly desirable that more exact scientific bases be developed for all classes of testing. Throughout the United States, many types of burners of widely varying efficiency are used in determining the candle-power of commercial gas. This efficiency depends not only on the type of burner, but also on the quality of the gas to be tested and the exact condition of the test. In consequence of the large number of burners available and used for testing gases and the uncertainty of the relative values obtained by the different types, this paper will endeavor to show the approximate relative values obtained on certain of the more efficient test burners when used on coal, water and mixed gases.

Mr. C. O. Bond, in the *Proceedings* of this Institute, 1908, p. 396, gives the following list of burners as being in use throughout this country for testing gas candle-power:

"Excavated Head 6 ft., 7 ft. and 8 ft.

Bray L. P. 7 ft., 8 ft., Union Jet, 6 ft. Special and No. 5 Union Jet.

Bray H. P. 8 ft.

Laubach & Hilpert Excavated Head.

Sugg Table Top.

Sugg Argands "D," old and new style, "E" and "F."

No. 2 Metropolitan Argand." (Carpenter patent.)

#### (B) METHODS OF DETERMINING CANDLE-POWER.

Before considering the relations between the various test burners, a brief discussion of the method of taking the candle-power of gas can be very profitably taken up.

The method of determining the photogenic power of a gas is by comparing the gas as burned at a rate of 5 cu. ft. per hour in a test burner, either directly or indirectly with one of several so-called primary standards, by means of a photometer bar.

Aside from errors, due to incorrect adjustment of the primary or secondary standards and personal equation, there are errors incident to the test burner itself. These variables will be taken up separately later, but mention of the following may be made here; improper setting on the bar with respect to the zero mark; burner or chimney or both not set vertical or concentric with the flame, causing irregular flame shape and "ghosts"; improper adjustment of the rate and (for Argand burners particularly) wrong size of chimney.

Out of the large number of burners that could be used for testing the candle-power of gas, by far the greater number can be discarded as poor in manufacture and exceedingly inefficient. The remaining types are divided into two classes—open flame and Argands. Of these, the open flame are more suitable for gases of 20 candles and over and the Argands for leaner gases, particularly coal gas.

*Open Flame Burners.*—Fig. 1 shows five types of open flame burners which give a reasonably high efficiency for their



class on all gases. Inasmuch as this type of burner permits unrestricted free access of air to the flame, up to a certain limit, a lower efficiency may be expected than for burners having a more restricted air supply, such as the Argand type.

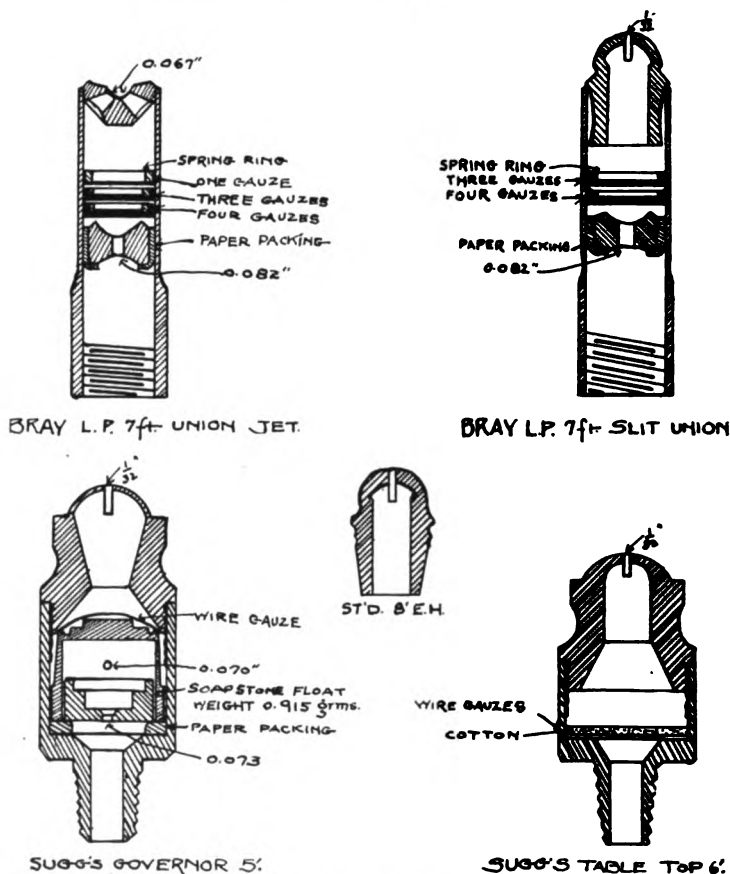


Fig. 1.—Open flame burners. Page 3.

When the gas becomes so rich that the air supply of the Argand burner becomes insufficient for combustion without smoking, the open flame will show the higher efficiency. In order to restrict somewhat the air supply to the base of the

flame, the Sugg "table top" burner is designed with a flat circular area to deflect the air to the outside of the flame. The lower the pressure necessary to obtain the requisite flow of gas through the tip and consequently the lower the speed at which the gas leaves the slit or orifice, the less air there will be entrained at the base of the flame, with a resultant higher efficiency of the burner. Of course, for very rich gases this air entrainment is necessary to burn the gas without smoking, or else a smaller burner might be used that permits equal access of air to a smaller amount of gas—*i. e.*, for a 40 to 50 candle-power oil gas, a 1¼-ft. tip is used instead of the usual 7 or 8 ft. tip.

From various tests made on open flame burners, especially of the excavated head type, it has been found that there can be obtained from a commercial package about 50 per cent. of burner tips that will vary less than 1 per cent. plus or minus from the mean candle-power of those mechanically perfect.

*Argand Burners.*—In Fig. 2 are shown three types of Sugg Argand burners, the "D" low and "D" high cone and "F" high cone and the Carpenter patent No. 2 Metropolitan Argand test burner. The "D" and "F" Suggs are two of a series which run from "A" to "NN," each letter having a corresponding consumption, and the construction of which is so designed as to admit the proper air supply necessary to consume coal gas of about 16 candle-power (as determined on that burner) at the scheduled rate. Accordingly, each burner should be supplied with the particular size of chimney specified for use. As the candle-power of the gas must be determined at a 5 ft. per hour rate of consumption, one is practically limited to the three burners shown. The "D" burner is fitted with a steatite tip containing 24 No. 54 Morse drill holes and the "F" with 30 No. 53 Morse drill holes. The high and low cone burners differ principally in the height of the top of the steatite tip above the base of the burner, the high cone being one inch higher than the low cone, with consequent greater resistance to the inner air supply.

The No. 2 Metropolitan Argand burner is a scientifically designed "D" type burner, having a shutter which regulates the air supply to the inner and outer primary air channels, ad-

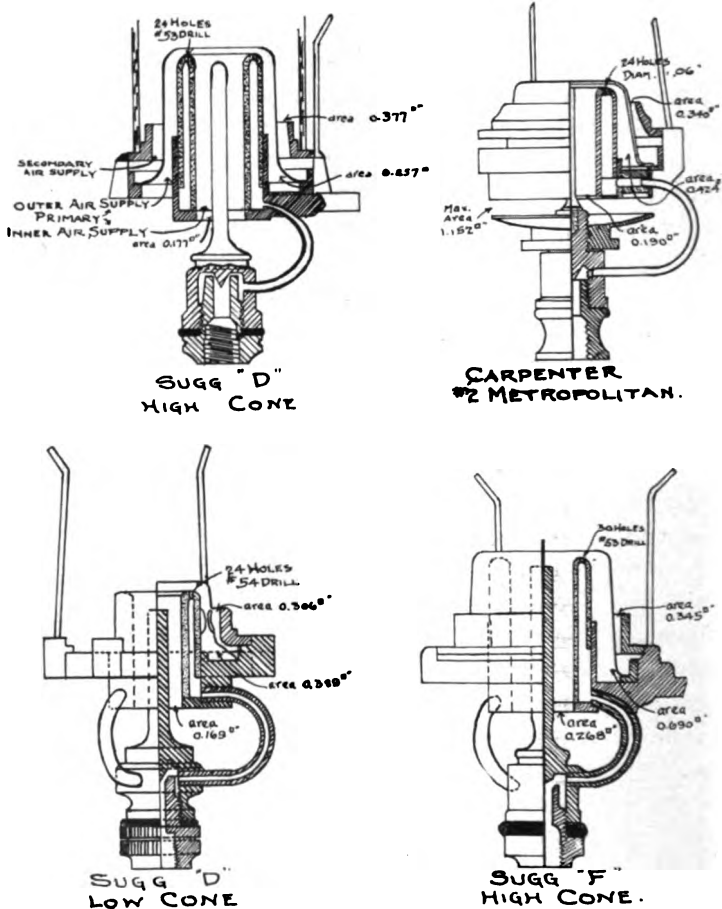


Fig. 2.—Argand burners. Page 5.

justable according to the richness of the gas. It stands to reason, however, that a burner whose air supply is so restricted as to raise its comparative efficiency on a lean gas, will fail as a test burner at an earlier point in the enrichment series, each

reaching its maximum when a balance is obtained between its normal maximum air supply and the air required for most efficient combustion. In the No. 2 Metropolitan Argand, this regulation for most efficient combustion is obtained within quite wide limits, so that, as is natural to expect, such a burner will attain higher efficiencies on all burners up to its maximum limit than less scientifically designed burners. In fact, the No. 2 Metropolitan burner is the only burner obtainable (if we except the Bengel and St. Claire burners of the French and the Grafton of the English) which is not a converted commercial burner, but a burner designed especially for testing.

#### (C) UNIFORMITY AND VARIATION OF BURNERS.

Due to the difference of efficiency obtained from burners of different types, there arise smaller or greater errors in the differences of efficiencies in burners of the same type. This is not included the increase or decrease of efficiency with age—an element more or less dependent on the care of the burner while in use or storage. This error is readily discovered and corrected in the open flame burner in the Argand. In an open flame burner, the gas supply is generally affected by poor or careless workmanship, and in the Argand type, slight variations in the sizes and positions of the cast parts and their relative positions may change the air channels as materially to affect the efficiency of combustion. These details of construction cannot be determined without a minute check of all measurements and comparison of same between burners.

The following table are shown comparative data obtained from several Sugg "D" low cone burners on coal gas and gas.

Burner No.	Corrected candle-power		
	1 st. Coal gas	2 nd. Coal gas	Water gas
1	12.0	12.5	19.4
2	12.0	—	19.4
3	12.0	—	18.7
4	13.4	13.4	Smoky
5	11.3	12.7	17.3
6	11.8	12.6	18.4
7	12.0	12.5	19.0
8	12.4	12.5	—
9	12.6	12.8	Smoky
10	12.0	12.4	Smoky

Of the above burners Nos. 1, 2, 3 and 4 were of American make and Nos. 5, 6, 7, 8, 9 and 10 English. Nos. 1, 2 and 3 were supposedly absolutely similar, while No. 4 was so assembled as to reduce the inner primary air supply with consequent increase of efficiency on lean gases and lower maximum candle-power on which the burner could be used. The body castings of the American burners are of brass and those of the English are of a white metal of low melting point.

It will be noted that the results obtained on the second run on coal gas show more uniform results than the first test. This is due to two causes: (a) number of spacing washers used and (b) length of time burning at proper consumption.

In the first coal gas test, the burners were photometered with the number of washers as found. The washer question was investigated because of the great discrepancies observed in burners apparently identical in construction. It was found that, although the number of washers for maximum efficiency could be changed so as to vary the burner pressure 1.5/10 to 2.0/10 in. from the mean, if the number was increased or decreased beyond these limits while still burning 5 cu. ft. per hour, the efficiency of the burners fell off markedly. The burners, therefore, were all adjusted with the number of washers that gave the mean reading between the upper and lower limits.

In order to obtain a comparison of different Metropolitan burners, where the possibility of imperfect and personal error

of adjustment may enter, two new burners, Nos. 1507 and 1525, were obtained to check against two old burners, Nos. 329 and 348. Two tests were made on coal gas, six days apart, and one on a mixed gas, the results of which are given in the following table.

Burners No.	Coal gas		Mixed gas
	1st test	2nd test	
329	19.2	16.8	21.5
	19.1	16.85	21.55
348			
1,507	18.6	16.5	21.0
	18.5	16.55	21.05
1,525			
B. t. u. of gas	606	581	635

This shows that the burner should be somewhat aged in order to give uniform results, as a new burner reads somewhat lower than an old one until the passages, particularly the steatite tip, become saturated, as their scrubbing action may be similar to new piping.

An interesting point in the adjustment of a No. 2 Metropolitan burner is shown below. The consumption was set at 5 ft. and the flame adjusted to different heights by the air shutter, candle-power being taken at various heights from 3 in. up until the flame smoked.

Height of flame	Candle-power
3"	12.0
3¼"	13.6
3½"	14.9
3¾" to 4"	15.8
4¼" to 4½"	16.4
5" to smoking.	16.4

The height of the last three readings are given between limits as the flame tails out considerably as the air supply is cut down. The results show that there is a variation of about ¾ in. in the flame height permissible at its upper limit, where no appreciable difference in candle-power will be noted, and nullifies to a certain extent the difference in judgment of different observers as to the correct "just below smoking" point.

As to the heating-up effect, the same general result is

obtained with test burners as with various types of flame standards, the light emitted becoming constant after about 5 or 6 minutes burning at its correct consumption. Several runs were made with the initial condition of the burner both cold and overheated. In each case, the consumption was adjusted to exactly 5 cu. ft. before the test commenced. In the heating test the burner was adjusted hot and turned out. After cooling down the burner was relighted and readings taken rapidly for one minute, after which readings were taken every half minute until they reached a constant value. On the cooling test, the burner was considerably overheated by burning through a separate supply without chimney in place.

Test	Candle-power	
	Heating up	Cooling down
1st minute.....	9.5	14.8
	10.4	14.6
	11.1	14.6
	11.5	14.1
2nd .....	11.8	13.9
2½ .....	12.1	13.5
3rd .....	12.2	13.5
3½ .....	12.2	12.9
4th .....	12.1	12.8
4½ .....	12.1	12.8

NOTE:—Tests made on different gas samples.

This shows that a burner should burn at its correct rate for at least 5 minutes before observations are begun. For the No. 2 Metropolitan burner, 15 minutes is specified in the instructions for use.

#### (D) EFFECT OF VARYING CONSUMPTION.

As might be expected, on any appliance having a fixed or restricted air supply, the efficiency will not remain the same on all consumptions, nor will the consumption for maximum efficiency remain the same for gases of varying degrees of richness in those constituents that create the luminous effects. In Fig. 3 horizontal candle-powers corrected to a rate of 5 cu. ft. per hour of an 8 ft. E. H. tip, a Sugg "D" low cone, a Sugg "D" high cone, a Sugg "F" high cone and a No.

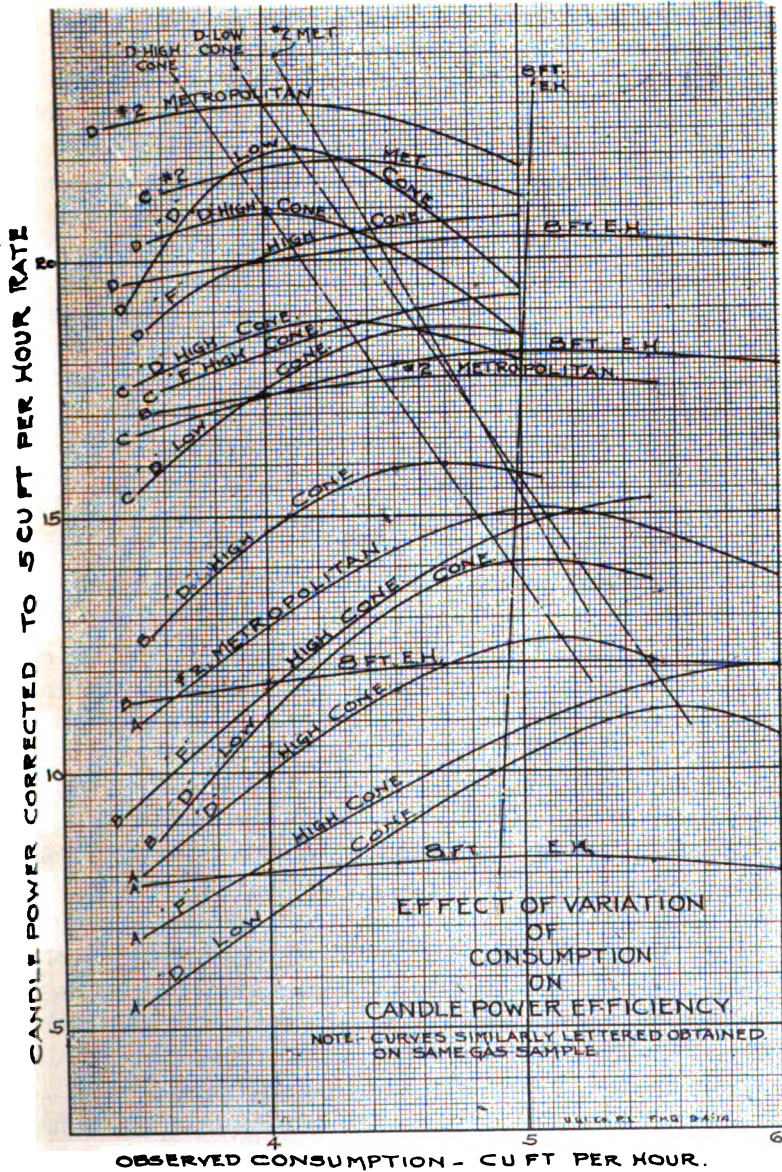


Fig. 3. Page 388.



Metropolitan burner are plotted against uncorrected observed consumptions between 3 and 6 cu. ft. per hour. From the theory of the burner, the temperature and barometer changes (assuming constant humidity percentage) will not affect the efficiency, as the relative actual volumes of gas and air will be affected equally, so that the gas-air ratio will remain constant for that burner. However, as the consumption is increased relative to the *fixed* air supply, the efficiency of the burner will increase until an air-gas ratio is reached that gives a maximum efficiency, after which the efficiency will fall off. Now, as a richer gas is used and a greater amount of air is required, that point of maximum efficiency will occur at a lower consumption, and if the gas is sufficiently rich, it will be impossible to burn it in the burner at the required rate for photometric purposes, owing to insufficient air supply. From the curves, it can be seen that the test burners there shown, give their maximum efficiency at the 5 cu. ft. per hour rate for one gas only, the lean gases being on the ascending, and the richer gases on the descending, portions of the respective curves.

The errors which enter into a photometric observation taken on a burner when on an ascending or descending portion of the curve, may be greatly aggravated by slight variations in the consumption from the exact rate. Also, as the curve becomes steeper the further the point on it lies from the maximum, the closer the observed consumption should lie to the exact amount of 5 cu. ft.

By drawing a line through the points of maximum efficiency of each burner, points can be determined for the consumption giving the maximum efficiency on gases of varying richness, or on what candle-power of gases each burner will give its maximum efficiency at the 5 cu. ft. per hour rate.

The lines so drawn, show clearly that the Argand burners, as at present designed, are distinctly for use on coal gas from 12 to 18 candles, as observed on these burners when burned at a 5 cu. ft. rate. On the other hand, however, certain sizes

(7 ft. and 8 ft. tips) of open flame burners continue to show a maximum efficiency close to the 5 cu. ft. rate on all gases. For the smaller sizes, this rate is lower, and for the larger, the rate higher than 5 cu. ft. per hour. The confusion of curves existing at times at the normal burning rate will show why it is at times difficult to determine the burner best suited for the gas, and the apparent paradoxes and conflicting results on burners of different types giving about the same efficiency at that point. The "F" size Sugg Argand is designed for a consumption of  $6\frac{1}{4}$  cu. ft. per hour, corresponding to the 5 ft. rate of the "D" size, a point brought out by the curves in Fig. 3. The adjustable feature for the inner air supply of the Carpenter burner flattens its curve somewhat and decreases the angle between its maximum efficiency line and the ordinate axis.

#### (E) COMPARISON OF VARIOUS BURNERS ON COAL, WATER AND MIXED GASES.

In Figs. 4, 5 and 6 are shown curves of candle-power obtained on coal, water and mixed gases from Sugg Argands "D" (high and low cone), "F" (high cone), No. 2 Metropolitan burner and 8 ft. E. H. tips. On the mixed gas chart (in addition) No. 7 L. P. and H. P. Bray Union Jet burners are shown. The basis of all the readings is the candle-power obtained from the 8 ft. E. H. tip, as that was found to be among the most efficient of open flame burners and was subject to fewer variables in determining candle-power, although at the same time, less efficient than the Argands. This plotting makes it more readily possible to determine the gain in candle-power obtainable by using one of the Argands. In the actual plot, results obtained from the 8 ft. tip are shown by a straight 45 deg. line, starting at the origin.

The points on the curves were obtained by various means. Straight works coal gas was used for some points and the same gas mixed with varying proportions of air up to 20 per cent. was also used.

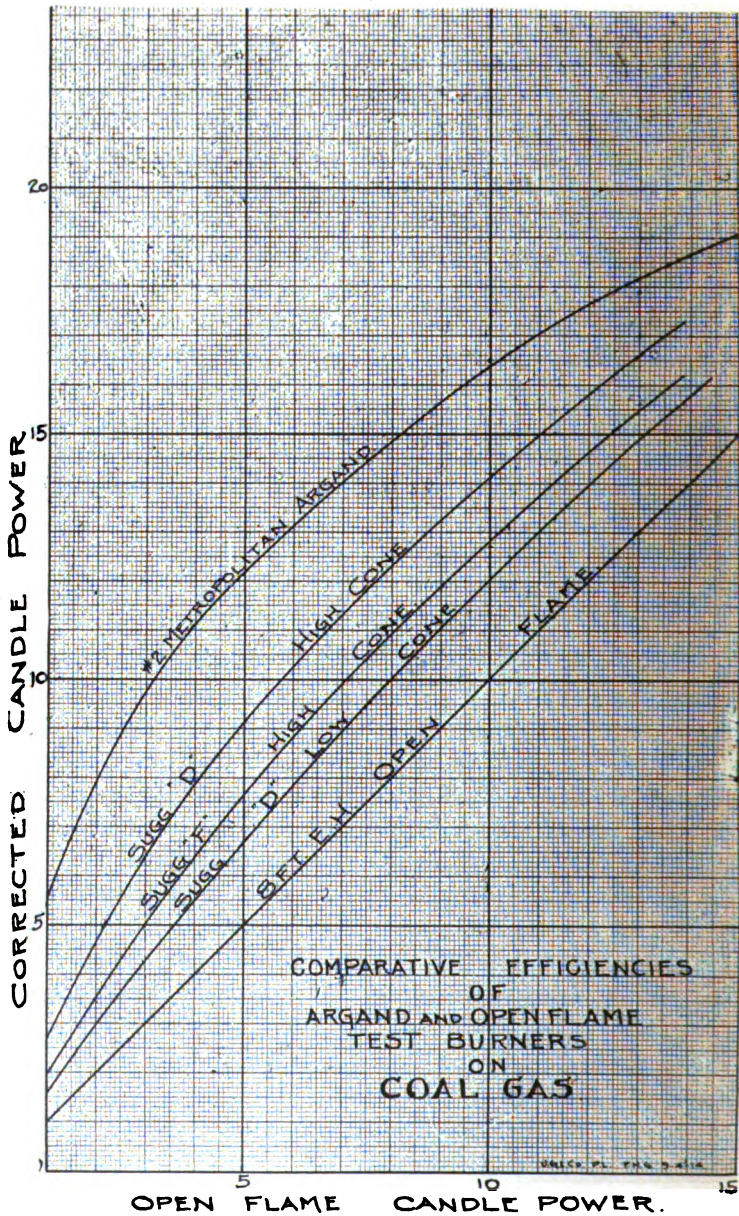


Fig. 4. Page 391.



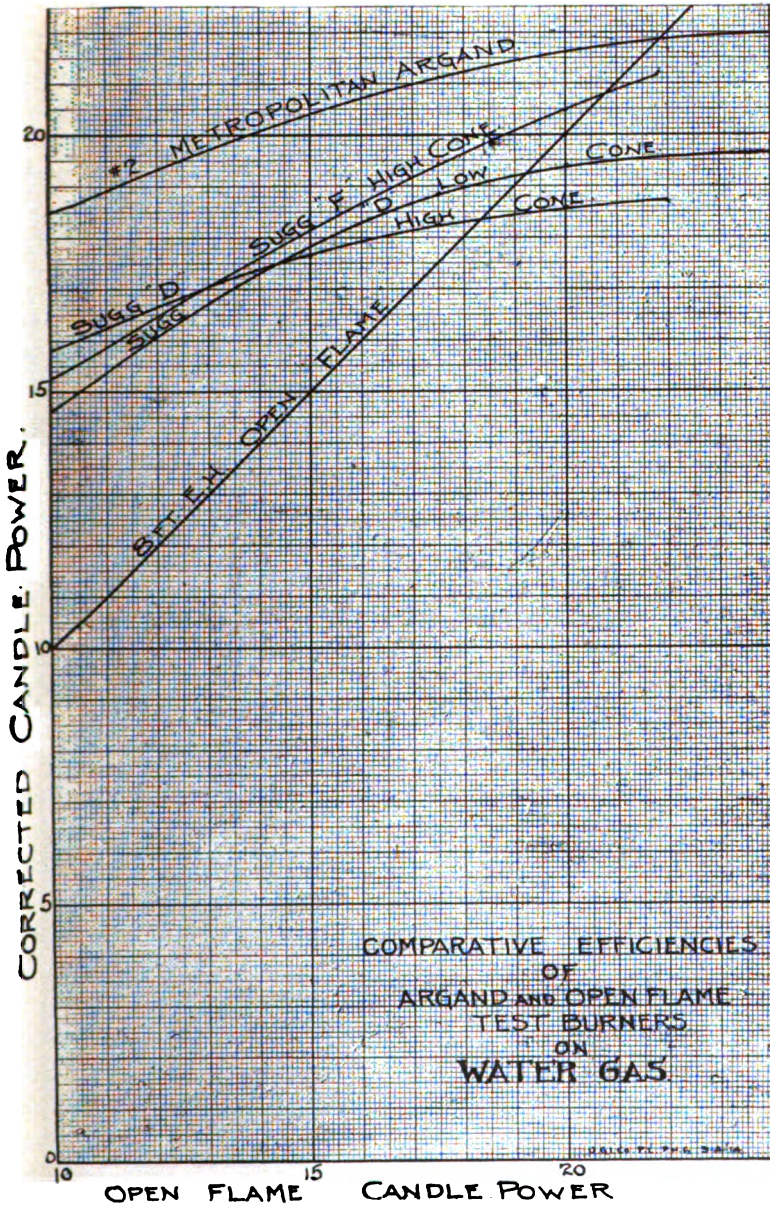


Fig. 5. Page 391.

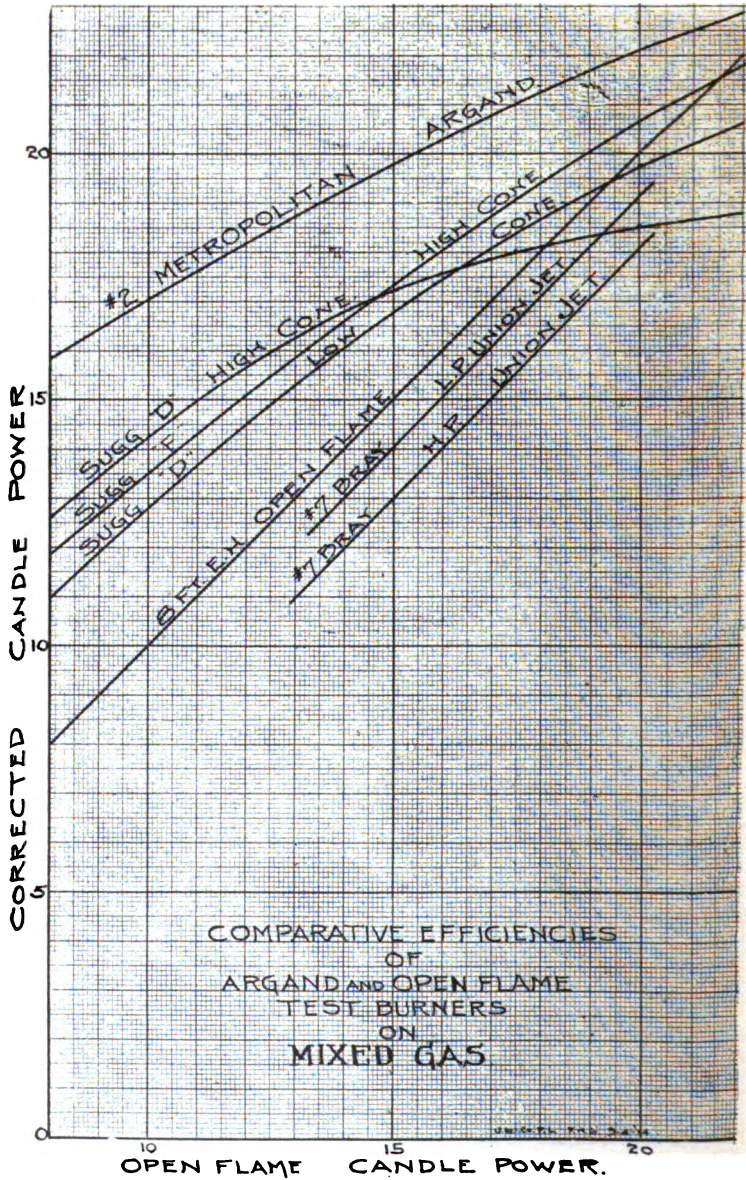


Fig. 6. Page 391.



Mixtures of coal gas and methane (natural gas) were tried, but the results obtained differed so widely (owing to large amount of air required for combustion), that they could be treated only as extraordinary conditions. On mixtures containing as low as 20 per cent. natural gas, it was found that the Argand burners could not be used without flaming at the top of the chimney.

The water gas variations were obtained from the works make, mixtures of rich carbureted water gas and blue water gas and mixtures of carbureted water gas and air.

The mixed gas variations were obtained by mixing standard samples of coal and water gas in various proportions and by mixtures of rich mixed gas and air.

All candle-power determinations were made on a regular 60 in. bar photometer against a pentane lamp standard. The burners were selected as the average of those at hand in first class condition and showing a high average candle-power. Inasmuch as 6 in. and 7 in. chimneys are supplied for the Sugg burners by the agents, the relative advantages of the two types were first ascertained, with the following results:

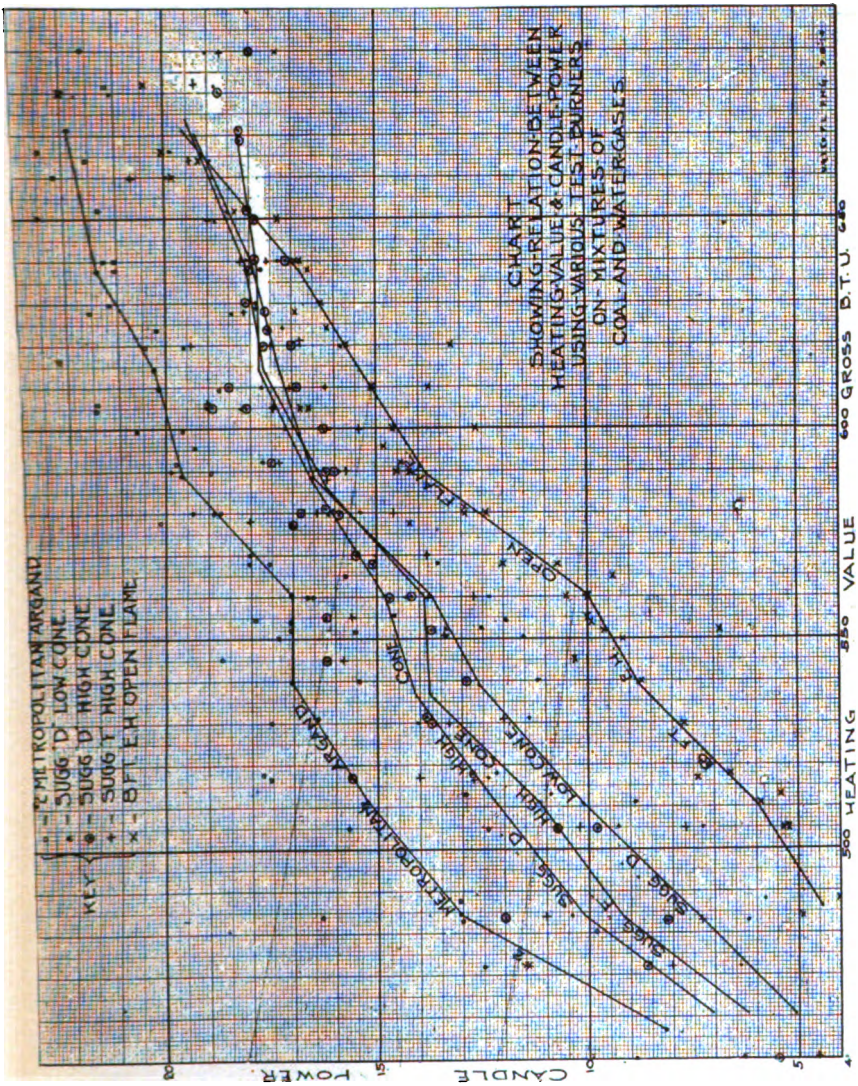
The 6 in. chimney gives the best efficiency on the "D" burners up to about 16 candles, above which the 7 in. chimney becomes the most efficient. For the richer gases, such as carbureted water gas of 18-22 candles, the 7 in. chimney was found necessary in order to burn the gas at all without smoking. With the "F" burner the 6 in. chimney gave results only slightly different from the 7 in. over the entire range shown.

As it was found impracticable without enormous expenditure of time to obtain similar curves for all open flame burners, a sample of each of a large number of types was tested on one sample each of coal, mixed and water gases at the established 5 ft. rate. The results obtained from the most efficient sizes of each type are tabulated on the following page.

Make	Type	Size	Coal gas	Mixed gas	Water
Von Schwarz	Excavated head	7	12.8	17.8	20.0
		8	13.2	18.2	20.0
		10	13.9	18.1	21.0
		8	12.9	17.5	20.0
Bray	H. P. slit union	7	12.6	17.5	19.0
		7	12.6	17.4	19.0
	L. P. slit union	8	13.5	18.3	20.0
		7	12.1	17.5	19.0
Bray	H. P. union jet	8	12.8	17.7	20.0
		7	12.5	16.7	18.0
Bray	L. P. union jet	8	11.9	16.1	17.0
		8	12.2	16.3	16.0
Bray	Market	9	12.2	16.1	16.0
		7	12.5	17.2	21.0
Gas Tip & S. L. Co.	Aluminum	8	12.7	17.3	21.0
		5	13.4	16.1	18.0
Sugg	Table top	6	14.1	17.1	18.0
		5	13.2	17.1	20.0
Sugg	Governor	6	13.3	17.0	20.0
			17.8	21.1	21.0
Metropolitan	No. 2		15.6	18.1	20.0
Sugg "D"	Low cone		15.8	17.8	19.0
	High cone		16.0	18.2	20.0
Sugg "F"	High cone				

By comparing the list on page 386 with the above table can be readily seen where differences of operating results might arise.

In view of the fact that the curves of the various burners do not bear any direct relation to each other, it was thought possible that one of the burners might bear a more definite relation to the heating value than the others. According to the points obtained on various mixtures of coal and water gases were plotted in Fig. 7. The dispersion of points is even greater than before, although a definite trend can be observed for each burner, as shown in the broken curves traced. However it is obvious that this method must fail where the composition of the gas is such that the increase of heating value is due to a saturated hydrocarbon whose photogenic value is lower than the average, or even negligible. In fact, previous efforts along this line have shown that even for close



**Fig. 7. Page 396.**



related gases made by the same process, the relation between heating value and candle-power value is not by any means a definite ratio, although it can be approximated. Also, the burners here show the same relative efficiencies as were given on the curves for the individual gases. The offsets in the curves can possibly be accounted for by reference to the coal and water gas curves. The curve itself is a combination of the two (coal and water gases) which do not coincide; the offset is probably the connecting link between the two. In spite of the fact that a curve may be assumed, the dispersion of the individual points shows how hazardous a proceeding it would be to try to deduce candle-power from B. t. u. or vice versa.

#### (F) EFFECT OF HUMIDITY ON FLAME BURNERS.

It has been stated by various authorities that, where candle-power determinations are made with flame standards and flame test burners, the relative humidity corrections of the two create a negligible error. To ascertain if such were the case, several tests were made on the Sugg "D" (high and low cone), the No. 2 Metropolitan and an open flame burner, to determine approximately the correction to be made on each for increase of atmospheric humidity above the assumed normal of 8 liters of water vapor per cubic meter of dry air. Inasmuch as the determinations were made in the summer time when the humidity content of the air is high, the lower values (3 to 10 liters) could be satisfactorily obtained only on rare occasions by artificial means. In all cases, the results were so comparable that this may be considered an unimportant detail.

Determinations were made on coal gas against an electric standard, the test burner being enclosed in a chamber in which the humidity of the air supply could be raised at will and kept constant for a sufficient length of time to obtain a series of readings under practically constant conditions.

In the results, the value of " $a$ " is determined for the formula:

$$I_1 = I_n [1 - a(e - 8.0)]$$

where  $I_n$  = horizontal intensity at 8 liters.

$I_1$  = " " "  $e$  liters.

$e$  = observed liters  $H_2O$  per cu. m. of dry air.

$a$  = constant.

The following approximate values of " $a$ " were obtained as the mean of the results from at least four sets of observations.

Open flame.....	$a = 0.0060$
Sugg "D" low cone .....	0.0063
Sugg "D" high cone .....	0.0061
No. 2 Metropolitan...	0.0046

As the Bureau of Standards gives a value of " $a$ " for the pentane lamp of 0.00567, it will be seen that the premise of the relative humidity correction being a negligible amount is sustained.

Before the International Photometric Commission, Messrs. Patterson, Haldane and Trotter presented a communication giving approximate corrections which are given below:

Harcourt pentane lamp .....	$a = 0.00625$
Hefner Amyl Acetate lamp.....	0.00625
No. 2 Metropolitan .....	0.00500
Flat flame.....	0.00910
Sperm candle.....	0.00200

### CONCLUSION.

The question of the final selection of a method for testing the candle-power of a gas may be approached from two sides. In one case, the scientific requirements demand the most efficient instrument for the purpose, and in the other, the commercial considerations require the use of simpler apparatus which shall cover the greatest range, and at the same time, entail the least liability to error.

The scientific basis appears the more logical. In determining the quality or characteristics of any substance, the scientific spirit requires us to use the method that is best adapted to develop the maximum amount of the particular quality or characteristic that is being measured. In determining the

salinity of a liquid, we use the method that brings out all of the salt in the liquid; in determining the heating value of a gas, we endeavor to develop all of the heat the gas is capable of producing. If, in any such case, a new method is devised which develops a larger amount or degree of the quality that is being measured, we are bound, from scientific considerations, to adopt this new method as being more accurate and correct in its determination of the particular quality.

Now, of course, the method so far discovered, that gives the greatest amount of light from a given gas is the method of incandescence, the gas being fed under high pressure. This method, however, is beyond the scope of this paper, which deals with the methods of developing the light-giving qualities of gas, with the principle of incandescence excluded. It follows, that in making this determination we should use, for each kind of gas, the method and apparatus that will develop all of the light-giving power of which the gas is capable. Of the burners now available, the No. 2 Metropolitan or Carpenter burner, from the fact that in this country there are very few cities in which a gas is distributed that is too rich to be burned correctly in it, best fulfills this condition. In those few cities using natural gas or other very lean gases, naturally nothing but incandescent burners are in use, and this question is not raised.

It still remains for some one to devise a burner that will show a maximum efficiency throughout the usual range of richness. The maximum efficiency attainable with burners at present available may be surpassed by a burner to be devised in the future.

Such a burner should also give its maximum efficiency on all gases at the same rate, or else the method should be followed of maintaining a constant intensity by varying the consumption and seeking a minimum consumption.

Where a dual system of standards is enforced, the burner should be chosen that will vary most in proportion to the calorific value. And it may be possible that for any one type of

gas, where the method of manufacture remains the same, a burner might be designed to vary the candle-power in proportion to the B. t. u.

The author's thanks are due to Messrs. J. L. Entwisle and D. V. L. Downs for their assistance in the photometric work.

(Mr. Gilpin read an abstract of his paper.)

(Mr. H. L. Underhill (New York) in the Chair.)

THE ACTING CHAIRMAN: Mr. Gilpin's paper is now open for discussion.

MR. C. W. HINMAN (Winchester, Mass.): We have practically had this question up ever since the discovery of gas. I have found it quite a question in my career. There are two methods of using test burners. One is to specify one particular burner to be used in testing all sorts of gas, and the other is to specify the burner that is best adapted to the gas. In the year 1880, the Massachusetts Legislature adopted my recommendations that the gas be tested with the burner best adapted to it and at the same time suitable for domestic use. That wasn't a very bad solution at that time, but as years rolled along, the result has been that the poor gas inspector has to go around with about half a dozen different burners and two different chimneys, and if the gas is just about on the established limit, he may spend all day testing it. On the other hand, if you adopt one particular burner to be used in testing all gas, it does justice in one case, but does not do it in another. The chemical composition of the gas influences largely the candle-power that you will get from the test. A burner that might be well adapted to a gas containing a little nitrogen and carbonic acid and a large amount of hydrogen and marsh gas would not be at all adapted to a gas containing a large quantity of benzol and a correspondingly large quantity of nitrogen and carbonic acid, and vice versa. In fact, in nearly every case to get the best results from the gas, you have got to have the one particular burner adapted to it. In other words, I don't think that there can be any one standard burner.

MR. M. E. MUELLER (Astoria, Long Island, N. Y.): In reading Mr. Gilpin's paper I became interested in the curves in Fig. 3, especially those relating to the Sugg F. high cone burner, as that is the burner we use in testing the candle-power of our coal gas. On our photometer we use a  $1/12$  cu. ft. meter and we have always worked between the limits of 58 and 62 seconds per revolution in taking candle-power. This corresponds to an uncorrected rate of 5.17 and 4.84 cu. ft. per hour respectively.

From the curve for the Sugg F high cone burner for gas "B," which, from the candle-power on an open flame burner of 12.6, I take to be straight coal gas, I find the corrected candle-power on the Sugg F burner to be 15.6 for the 62 second rate, and 16.1 for the 58 second rate, a difference of 0.6 candle, due to the variation in the gas rate, generally considered allowable. This seemed surprisingly large, and I had tests made on our burner and photometer, and the results check those from the curve in Fig. 3 very closely, indeed.

I next considered the influence of gas temperature on the rate of consumption. Assuming in Fig. 3 that the gas temperature at the meter was  $80^{\circ}$  F., the correction factor for which temperature is 0.946, the corrected rate at 58 seconds per revolution would be 4.89 cubic feet per hour. At  $70^{\circ}$  F. and 58 seconds per revolution, the corrected rate would be 5.04 cubic feet per hour, corresponding to an uncorrected rate of 5.32 at  $80^{\circ}$  F. or one revolution of the photometer meter in 56.4 seconds.

In the last two cases (temperature  $70^{\circ}$  F.—1 revolution in 58 seconds, and temperature  $80^{\circ}$  F.—1 revolution in 56.4 seconds) the actual amount of gas burned per hour is the same, yet in one case the rate is considered permissible and in the other not. According to the curve for this burner, this increased rate would add another to the candle-power of the gas, which if the gas were metered at  $70^{\circ}$  F. instead of at  $80^{\circ}$  F., would be allowable. In other words, a gas which on a Sugg F. burner tests 15.0 candle-power when metered at  $80^{\circ}$  F., at the rate

52 seconds per revolution, will, if metered at 70° F. and at 52 seconds per revolution, test approximately 15.8 candle-power, assuming, of course, that no drop occurs due to the varying of the temperature.

It seems to me reasonable, therefore, that in taking candle-power any restrictions on the gas rate should be based, not on the observed, but on the corrected, rate; also, that the rate should vary not only for different burners, but for gases of different candle-power tested in the same burner. The question then arises whether the most efficient rates for two gases of the same candle-power are the same. From Mr. Gilpin's paper, I gather that the most efficient rate depends largely on the amount of air required for combustion, and this, of course, is a function of the chemical composition of the gas and has nothing, or little, to do with its candle-power. We seem, therefore, to be as far as ever from making gas photometry an exact science.

Just one more point which may be of interest. A few years ago we made some tests with a Sugg F. burner by partially restricting the flow of air by covering the chimney with pieces of asbestos board in which holes of varying sizes had been

By selecting the smallest hole which allowed the gas to pass without smoking, results approaching those on a Metropolitan No. 2 burner can be obtained.

THE ACTING CHAIRMAN: Mr. Bond, have you anything to say?

MR. C. O. BOND (Philadelphia): I was very much interested in the remarks of the last speaker. It appears that, so long as the air is controlled, whether it be at the outlet or the inlet of this chimney, you will get equivalent results. It is interesting to have presented to us the errors which are commonly considered in taking candle-power with different burners, and I think it fastens more deeply upon us the obligation to decide on a standard burner, so long as we are even talking on a candle-power basis. If this paper shows—and it

seems to—that the Carpenter burner is the one which, under all circumstances, comes nearest to making the test that is to be considered the criterion of the gas in candle-power, then if there has not been fixed in this country a burner for national use, why not start a movement towards the adoption of this burner? A recommendation was made in the St. Louis meeting, I think, to have the Technical Committee confer on this matter with the Bureau of Standards, but for some reason it was never acted upon. I should like to see, if possible, a standard burner adopted throughout the country. It seems to me there are many advantages to be had from such a burner in the comparison of results, not only in our own works, but in comparison with other works, as it would serve to make more nearly comparable the results obtained in testing stations as well as those in your work between one town and another.

MR. A. S. MILLER (New York): I think all this discussion shows very clearly, if it shows anything, that the Public Service Commissions have been right in dropping the standard of illumination and going to the standard of heating power.

MR. BOND: After fully considering this paper and its recommendation of the Carpenter burner as the logical one for adoption in this country for the testing of gas, and recalling that the burner suggested by the Bureau of Standards in Circular 48 favors instead the 7- or 8-foot open flame burner, it seems to me that the question of the choice between these two burners is brought straight before this Institute for action, and I would recommend, and hope that the gentlemen present in this section will stand with me in this recommendation, that, as a result of this section meeting, there be brought before the American Gas Institute this question for consideration: Shall we favor as an Institute the adoption of the Carpenter burner, or shall we favor the 7- or 8-foot open flame burner as recommended by the Bureau of Standards?

THE ACTING CHAIRMAN: As the time is so short, we shall have to consider that at to-morrow's meeting. Is there any further discussion on Mr. Gilpin's paper?

A vote of thanks was then passed to Mr. Gilpin for his paper.

(For further discussion on Mr. Gilpin's paper, see pp. 720-721.)

A motion to adjourn is in order.

Adjourned, 5:30 P. M.



## MANUFACTURING SECTION.

Morning Session, Thursday, October 22.

CAPT. W. E. MCKAY (Boston), *Chairman*, Presiding.

MR. W. VAN ALAN CLARK (Astoria, Long Island, N. Y.),  
*Section Secretary*.

Chairman McKay called the meeting to order at 10.18 A. M.

THE CHAIRMAN: The first business on the program is the paper on "The Operation of Inclined Retorts," by Mr. Frank Huber, of Louisville, Ky.

### THE OPERATION OF INCLINED RETORTS.

In presenting this paper, I am endeavoring to lay before you actual experience of importance, during a period of 13 years and 6 months with the inclined retort system in Louisville, Kentucky. There are many points connected with this installation which will be of interest to you, the most prominent being the long duration of retorts and settings.

Before relating experience with inclines, I will explain briefly some incidents. The installation was designed and constructed under the direction and management of Mr. A. H. Barret, Chief Engineer of the Louisville Gas Company, who described it in a paper before the American Gas Light Association, October, 1900, at Denver, Colorado, entitled "An Installation of Inclined Retorts." Mr. Barret's paper will be recalled by many who attended the meeting, and can be referred to for closer details by those who have copies of the proceedings.

The installation consists of 20 benches of 6's; 15 in. x 23 in. top; 15 in. x 26 in. bottom; 18 ft. long; in 2 stacks, —10 benches each,—placed parallel, with a space of 25 ft. between stacks, allowing for working room on charging floor, and 13 ft., 10 in. working space between the benches and wall of building on discharging floor; No. 1 stack having an exposure on the south, and No. 2 stack an exposure on the north, the space on the east and west ends of the stacks being 11 ft.

3 in. to wall. The entire building had free exposure to the west until 1904, when the Water Gas Building was erected, which closed off 40 per cent. of the exposure. The east end was partially exposed, as the wall of the retort house was built on the old wall of the blacksmith shop. The distance from the ground level to the discharging floor is 13 ft. and to the charging floor 27 ft., 9¼ in.

Above the charging floor is placed 2 rows of coal hoppers; 1 bin for each bench, making 20 in all, capable of holding 48 hours supply. The coal is received in the storage shed (10,000 tons capacity), then hauled by 2.45 ton cars on narrow gauge track to receiving hoppers, where it is broken and crushed, elevated to a height of 73 ft., dumped in a horizontal trough, and conveyed on bridge to bins,—a distance of 120 ft.—by a push plate conveyor, then into another horizontal conveyor, one over each stack, distributing coal along the length of the 2 rows of hoppers. Each bin has a slide valve at the bottom, operated on the charging floor, for loading the portable retort chargers, of which there are 4—2 to each stack,—suspended from tracks above the benches. Each charger is so constructed as to hold 3 magazines of coal, charged into bottom, middle and top retorts. The chargers are usually loaded closest to the bench to be charged, and each 3 magazines of coal is called a load.

The coke is drawn from retorts to chutes in discharging floor, 2 chutes opposite each bench. It then drops to cars,—ground floor,—which are pushed to quenchers, and then to elevator, which is placed in the center of retort house,—north side. It is hoisted by hydraulic power to a height of 50 ft.; thence pushed over a bridge 40 ft. to the coke warehouse 30 ft. x 90 ft., with capacity of 50,000 bushels, divided into 5 compartments as follows: 22,000 bushels of lump coke, and all sizes as it comes from the retort house; 11,000 bushels of egg coke, 1½ in. to 2 in.; 5,700 bushels of nut coke, ¾ in. size; 5,700 bushels of breeze; and 5,700 bushels of pea coke, ⅜ in. size.

The lump coke, as it is taken from large bin to consumer, passes over perforated chutes with holes 2 in. in diameter, and all coke 2 in. and under in size, drops into pocket, there being 4 pockets under chutes of this bin. It is then collected by dump cars and conveyed to hopper at end of coke house, where it is re-elevated to the top with bucket elevator, and there it is separated with a revolving screen, dropping into bins as per sizes noted above.

The erection of the inclined retort house was started during 1899, and installation completed in 1900, the necessary time being taken to dry out flues and settings. We began carbonizing coal August 9th, 1900, and continued the operation until March 20th, 1914, when all plants in the city were closed down; artificial gas being displaced by natural gas from West Virginia.

As there are 2 stacks of benches, they are designated by numbers, 1 and 2; No. 1 bench in No. 1 stack starting from west end, and No. 1 bench in No. 2 stack starting from east end. Two benches in stack No. 1, Nos. 5 and 6, were the first to be lighted up. The idea was to start heating up benches from the center of each stack, gradually increasing the heat on each side of center until entire stack was in operation, thereby equalizing the strain on stack due to expansion. As more benches were needed, Nos. 5 and 6, in stack No. 2, were started in the same way.

*Dampers.*—On each bench, 4 flue dampers are provided, located at grade line; 2 in front, and 2 in back of bench. The discharging side of bench is called the front, and the charging side is called the back. The flue openings are each 5 in. x 20 in. These flue dampers are used to regulate the pull on the setting, and are closed when bench is not in use.

The 5 in. x 20 in. flues extend down to underground flues, having sumps to collect loose material. They are connected to a 15 in. x 18 in. flue, running under center of bench and out into main flue, which is connected to chimney, 4 ft. in diameter, and 75 ft. 6 in. above damper line. The draft in the

ney 3 ft. above grade, gave 6/10 in. water pull. Over top  
 e damper at grade line, with front slides open 6 in., there  
 0.25 in. water, and with the back dampers open 5 in., the  
 was 0.2 in. water. With this draft, primary dampers  
 opened in back of bench  $2\frac{1}{4}$  in. on each side; in front of  
 , 1 in. on each side, making a total area of 4 openings  
 .62 sq. in. Secondary dampers open in back of bench,  
 n. on each side, and on front of bench  $1\frac{1}{4}$  in. on each  
 making a total for the 4 openings of 29.74 sq. in. Air  
 ty of primary and secondary dampers being taken with



Clinker and relief bar doors, dampers and recuperators. Page 409  
 nometer fixed to a box which fitted around opening,  
 result being used for a guide or check on all benches.  
 raters are placed inside of bench, and clinkered every  
 rs in back of bench; Fig. 1 showing clinker door, re-  
 r door, secondary and primary air dampers, and re-  
 rs, which will be referred to later. The fuel bed aver-  
 5 ft. deep, and with dampers placed as just described—  
 rnace lid being open,—a flame would hover in and out  
 furnace door. The lower combustion chamber indi-  
 0.05 in. of water pull, the upper combustion chamber  
 g slight pressure.

The upper and lower combustion chambers were divided with a wall starting at the nostrils over the generator, and extending up around retorts to arch of bench, thus making each combustion chamber independent of the other. Tiles were placed over nostrils of upper combustion chamber, as conditions required, to regulate heats.

Outlet ports for waste gases into recuperators were closed  $\frac{2}{3}$  of the way, with sliding tiles down from the top, thereby forcing the hot gases from upper combustion chambers up around retorts, and down under the bottom retorts to lower outlet ports. This was done to utilize the heat as much as possible from the upper combustion chambers, along with the lower combustion chamber waste gases, it being necessary to carry the heat high in the lower part of retorts, due to the greater number of charges being the thickest at the shields. The above regulation could be changed according to conditions, by sliding damper, which was necessary at times, according to grade of coal used.

*Charging.*—Heats in benches were brought up according to damper regulations as before mentioned, and retorts charged light, gradually increasing the heat and also the charge. We started off carbonizing after heats were up, 625 and 650 lbs. of coal on 4 hours, but changed to 700 lbs. on 5 hours, and then 750 lbs. on 5 and 6 hours; the working basis being 5 hours. Charges were changed according to grade of coal received.

The work of starting new installation in August was very trying, due to the hot weather. There were some changes necessary in regard to getting rid of large quantities of coke through chutes to cars below floor. The work of changing chutes, which had to be done during operation of benches, held back the amount of work which was to be done by stokers. It was some time in October before we arrived at normal conditions after closing down old horizontal retort house.

*Working in Retort House.*—The task of stokers, 12 hours shift, was as follows:

- 1 Head stoker, or foreman—Day and night.
- 2 Gangs, 4 men each, stokers—Day and night.
- 3 Coke-car men—Day and night.
- 1 Hydraulic main man—Day and night.
- 1½ Clinkermen—Day only.
- 1½ Clinker helpers—Day only.

Stokers charged and discharged 9 retorts per hour per gang, keeping their standpipes open, filling furnaces, and leveling off coke, cleaning floors, and helping head stokers. The head stoker was in charge of retort house, and kept the pipes burnt out, scurfed and patched the retorts, and made out reports.

Coke men placed cars under chutes receiving coke from retorts, quenched coke, and took same to the coke house.

Hydraulic main man drew off tar once a day, keeping on seals, and had helpers 2 hours in the afternoon, to clean out heavy deposit.

Stokers working on the basis as before mentioned, were carbonizing  $10\frac{1}{8}$  tons of coal per man per 12 hours; this amount corresponding to 3 charger loads per gang of 4 men per hour. In establishing this basis of work, it was understood by the men that 3 loads per gang of 4 men was the amount of coal per hour, and it was necessary at different times of the year to reduce or increase carbonization, and proportion the amount of work as it might be.

We have had 4 and 3-men gangs, and at times we would have 2 4-men and 1 2-men gangs. The 2-men gangs would draw and charge in proportion. During the hot summer months of 1901, we had to reduce this task work from 9 retorts per hour per gang of 4 men to 6 retorts 1 hour, and 9 the next alternate hour.

This basis was established from the 15th of April to the 15th of October, and between that time, they were to draw the 9 retorts per hour as before. This satisfied the stokers, and was continued on to August, 1911, when environments of 8-hour system got the best of them, a strike ensued, and the outcome was a compromise with the company on a 10-hour

basis, *i. e.*, they drew and charged the same amount of coal per hour, but discontinued breaking down furnace fuel, and helping head stokers burn out pipes, and clean up floors. This



Fig. 2.—Sagging walls of combustion chambers. Page 413.

necessitated putting on one extra man to break down fires, and one to help head stoker, on each watch.

The results obtained from inclines here, like all benches,

show up best when new, and the most troublesome part of operation was maintaining heat. This was very noticeable in 1904, when heats began falling in several benches of stack

No. of Bench	Date of erection	Began Combustion	Let Down	Retorts Returned	Let Down	Combustion resumed	Let Down	Duration of Bench	Exhaustion of gas	Remarks
1	1900 January 10th	June 1900	January 1901	September 1901	March 1902	October 1902	March 1903	6 years 7 months	7 $\frac{1}{2}$ up. 1 $\frac{1}{2}$ mid. 14 $\frac{1}{2}$ low	Braced walls of combustion chamber Feb. 1905. Bench in good condition. Retorts torn out, combustion chamber walls secured.
2	1900 January 10th	June 1900	January 1901	September 1901	March 1902	October 1902	March 1903	5 years 7 months	5 $\frac{1}{2}$ up. 2 $\frac{1}{2}$ mid. 12 $\frac{1}{2}$ low	Same as bench 1.
3	1900 January 10th	June 1900	January 1901	September 1901	March 1902	October 1902	March 1903	5 years 7 months	5 $\frac{1}{2}$ up. 2 $\frac{1}{2}$ mid. 12 $\frac{1}{2}$ low	Same as bench 1.
4	1900 January 10th	June 1900	January 1901	September 1901	March 1902	October 1902	March 1903	5 years 7 months	5 $\frac{1}{2}$ up. 2 $\frac{1}{2}$ mid. 12 $\frac{1}{2}$ low	Retorts torn out.
5	1900 January 10th	June 1900	January 1901	September 1901	March 1902	October 1902	March 1903	5 years 7 months	5 $\frac{1}{2}$ up. 2 $\frac{1}{2}$ mid. 12 $\frac{1}{2}$ low	Retorts torn out.
6	1900 January 10th	June 1900	January 1901	September 1901	March 1902	October 1902	March 1903	5 years 7 months	5 $\frac{1}{2}$ up. 2 $\frac{1}{2}$ mid. 12 $\frac{1}{2}$ low	Retorts torn out.
7	1900 January 10th	June 1900	January 1901	September 1901	March 1902	October 1902	March 1903	5 years 7 months	5 $\frac{1}{2}$ up. 2 $\frac{1}{2}$ mid. 12 $\frac{1}{2}$ low	Retorts torn out.
8	1900 January 10th	June 1900	January 1901	September 1901	March 1902	October 1902	March 1903	5 years 7 months	5 $\frac{1}{2}$ up. 2 $\frac{1}{2}$ mid. 12 $\frac{1}{2}$ low	Retorts torn out.
9	1900 January 10th	June 1900	January 1901	September 1901	March 1902	October 1902	March 1903	5 years 7 months	5 $\frac{1}{2}$ up. 2 $\frac{1}{2}$ mid. 12 $\frac{1}{2}$ low	Retorts torn out.
10	1900 January 10th	June 1900	January 1901	September 1901	March 1902	October 1902	March 1903	5 years 7 months	5 $\frac{1}{2}$ up. 2 $\frac{1}{2}$ mid. 12 $\frac{1}{2}$ low	Retorts torn out.

Fig. 3.—Duration chart. Stack No. 1; first setting. Page 414.

No. 2. It was found on inspection that the combustion chamber walls were sagging in and closing off draft, due to lack of support, as shown by Fig. 2. While the retorts and



other parts of benches were in good condition, we tore out these settings and renewed retorts in benches 1, 2, 3, 4, 5, and 6—stack No. 2. We immediately started bracing walls of

No. of Bench	Date Retort Replaced	Retort Commenced	Let Down	Commenced Resumed Down	Let Down	Commenced Resumed Down	Let Down	Total Duration of Bench	Condition of retort	Remarks
1									Let down	Bench good on 5 hrs before letting down
2	1908 Oct 17th	1910 March 26th						3 years 4 months	5" up	Bench good on 5 hrs charge before letting down
3	1908 Oct 4th	1910 March 26th						3 years 4 months	5" up	Bench good on 5 hrs charge before letting down
4	1908 Oct 17th	1910 March 26th						3 years 4 months	5" up	Bench good on 5 hrs charge before letting down
5	1908 Oct 17th	1910 March 26th						3 years 4 months	5" up	Bench good on 5 hrs charge before letting down
6	1908 Oct 17th	1910 March 26th						3 years 4 months	5" up	Bench good on 5 hrs charge before letting down
7	1905 Jan 20th	1906 March 26th						1 year 5 months	1" up	Bench in very good condition
8	1905 Jan 20th	1906 March 26th						1 year 5 months	1" up	Bench in very good condition
9	1905 Jan 20th	1906 March 26th						1 year 5 months	1" up	Bench in very good condition
10	1904 Sept. 19th	1905 Jan 6th						3 months 2 days	2" up	Bench will need new setting

Fig. 4. Duration chart. Stack No. 1; second setting. Page 414.

combustion chambers of the balance of benches, and extended the life, as will be seen by referring to the duration charts, Figs. 3, 4, 5 and 6.



ring to arch tile settings, as shown in Fig. 8. It will be seen that each saddle forms an arch around retorts, and weights above were transmitted to side walls, having a tendency to

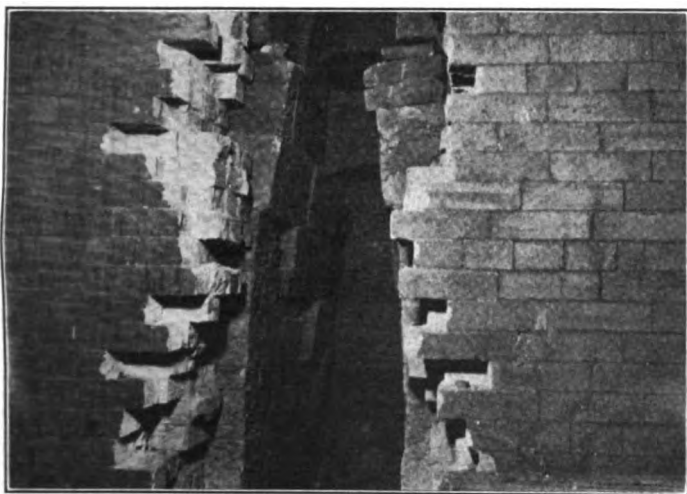
**B 2**

No	Date of Bench	Began	Let Down	Bottoming	Let Down	Bottoming	Let Down	Total Duration of Use	Condition of	Remarks
1	1904 April	June 25 <sup>th</sup> 1904	Oct 31 <sup>st</sup> 1904	Nov 29 <sup>th</sup> 1904	Nov 18 <sup>th</sup> 1907	Mar 20 <sup>th</sup> 1914	8 years 11 months 25 days	up. 25' mid. 1' low.	Bench good with 6 hr charges before letting down.	
2	1904 May	Oct 22 <sup>nd</sup> 1904	Nov 20 <sup>th</sup> 1904	Nov 29 <sup>th</sup> 1904	Mar 20 <sup>th</sup> 1914	8 years 11 months 25 days	up. 25' mid. 1' low.	Bench good on 6 hr before letting down.		
3	1904 June	Oct 22 <sup>nd</sup> 1904	Nov 20 <sup>th</sup> 1904	Nov 29 <sup>th</sup> 1904	Mar 20 <sup>th</sup> 1914	8 years 11 months 25 days	up. 25' mid. 1' low.	Same as bench 2		
4	1904 July	Oct 22 <sup>nd</sup> 1904	Nov 20 <sup>th</sup> 1904	Nov 29 <sup>th</sup> 1904	Mar 20 <sup>th</sup> 1914	8 years 11 months 25 days	up. 25' mid. 1' low.	Same as bench 2		
5	1904 Aug	Oct 22 <sup>nd</sup> 1904	Nov 20 <sup>th</sup> 1904	Nov 29 <sup>th</sup> 1904	Mar 20 <sup>th</sup> 1914	8 years 11 months 25 days	up. 25' mid. 1' low.	Same as bench 2		
6	1904 Aug	Oct 22 <sup>nd</sup> 1904	Nov 20 <sup>th</sup> 1904	Nov 29 <sup>th</sup> 1904	Mar 20 <sup>th</sup> 1914	8 years 11 months 25 days	up. 25' mid. 1' low.	Bench good on 7 hrs before letting down.		
7	1904 Aug	Oct 22 <sup>nd</sup> 1904	Nov 20 <sup>th</sup> 1904	Nov 29 <sup>th</sup> 1904	Mar 20 <sup>th</sup> 1914	8 years 11 months 25 days	up. 25' mid. 1' low.	Bench good on 5 hrs. before letting down.		
8								up. 25' mid. 1' low.	Bench in good condition for use.	
9	Aug 1904	Dec. 1904	Jan 14 <sup>th</sup> 1905					up. 25' mid. 1' low.	Same as bench 9	
10	April 1906	Sept 1906	Mar 1907					up. 25' mid. 1' low.	Same as bench 9	

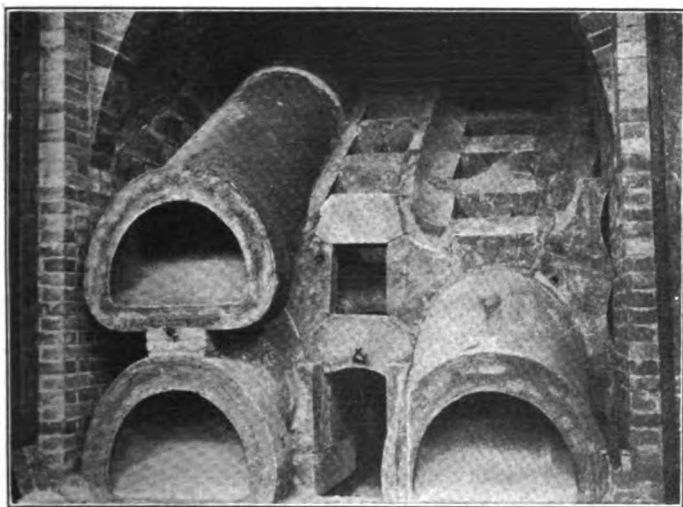
Fig. 6. Duration chart. Stack No. 2; second setting. Page 414.

hold saddle of upper retorts, lower inside portion of bottom retort acting as skew-back.

The failure to detect the caving in of combustion chamber walls before it got too far to brace them will explain why the



**Fig. 7.**—Combustion chamber before bracing. Page 415.



**Fig. 8.**—Arch tile settings. Page 416.

life of these benches was not extended longer. Benches 4 and 5 in stack No. 1 were exceptions, being fired up once. These 2 benches were not rebraced, though on inspecting them, walls were found caved in, but not sufficient to retard draft.

In renewing settings, we lowered the base and brace tiles, as shown in Fig. 9, bringing the tiles on a line with bottom of retort, instead of as shown by Fig. 8, the first design.

By referring to the duration charts, it will be seen that benches ran from 2 years 5 months to 10 years, averaging

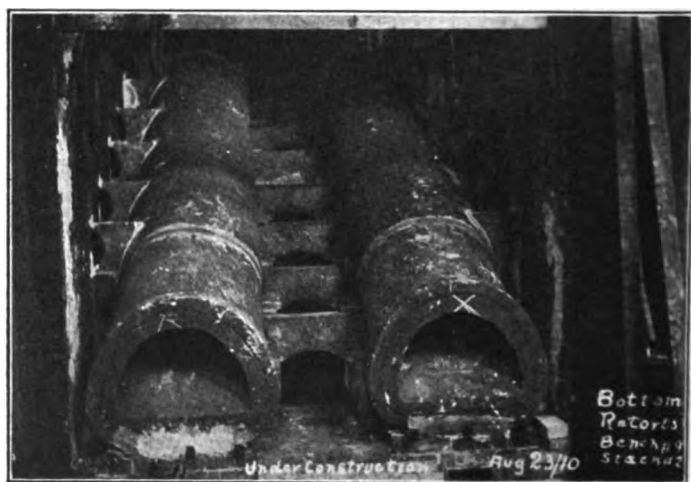


Fig. 9.—Settings after renewals. Page 418.

5 years 5 months, and I feel safe in saying that an average of 6 years could have been attained had more bracing been provided in combustion chamber.

*Patching Leaks.*—Benches after having been let down and fired several times, caused quite a bit of trouble, due to expansion and contraction, and leaks in recuperator partitions occurred, short-circuiting the secondary air into waste gas side, causing heats to drop and fuel to increase. These leaks usually occurred in the vertical joints of partition tiles (see Fig. 1) within 4 ft. of main damper, and were patched through

openings in benches provided for the purpose of cleaning and inspection.

As most of the leaks were low, they were patched from either the primary or secondary air opening, front or back. For close inspection of short-circuiting, we made a leak detector, by fixing up a piece of  $\frac{1}{2}$  in. pipe, about 12 ft. long, connecting gas hose, and a burner tip on ends of pipe. This light on the end of pipe would be inserted in the horizontal flue, passing it over each joint, and wherever a leak was found, the flame would be sucked in, and the usual method of patching was done. This proved to be the most efficient way of finding leaks.

A note book was provided, and on each bench we kept all record of leaks. When benches needed attention, reference would be made to leaks previously patched.

Joints of upper sections of retorts were usually very wide at times, open 2 in. when bench was fired up the second time. There were no buck bars or rails across the upper mouth-pieces, or back of bench as it is called, rails being placed horizontally between bottom, middle, and top retorts of lower side, or front of bench only. Retorts being inclined 32 deg. to back had tendency to move down the front, due to gravity, and the bars held back this force. We have provided iron buck bars on several benches when mouth-pieces were coming loose, due to age of bench, and these were put on when benches were hot.

*Patching Lower End of Bottom and Middle Retorts due to Wear of Poker.*—When retorts are free of carbon in the mouth, very little irritation of coke with poker is necessary, *i. e.*, when bottom of retorts are smooth. At times, charges will slip out when doors are open, pushing shield or stopper out, before the stoker has chance to get to shield. Charges not being thoroughly coked, or banked high against stopper, require the use of  $\frac{3}{4}$  in. poker 10 ft. long to get coke started, and assistance is necessary from stoker above on charging floor. This poking at coke on discharging floor produces a

wear on the retorts close to the mouth-piece, due to angle at which the stoker uses the poker in loosening the coke. This part of retort is usually affected about 12 in. above mouth-piece, and becomes thin. Holes resulted, and repairs were made while bench was in use, by breaking out this thin piece and inserting tile, as shown of bench 9, stack No. 2, in Fig. 10.

There was no occasion to repair top retort in this manner, as the retorts were more in line with the poker used by the stoker.

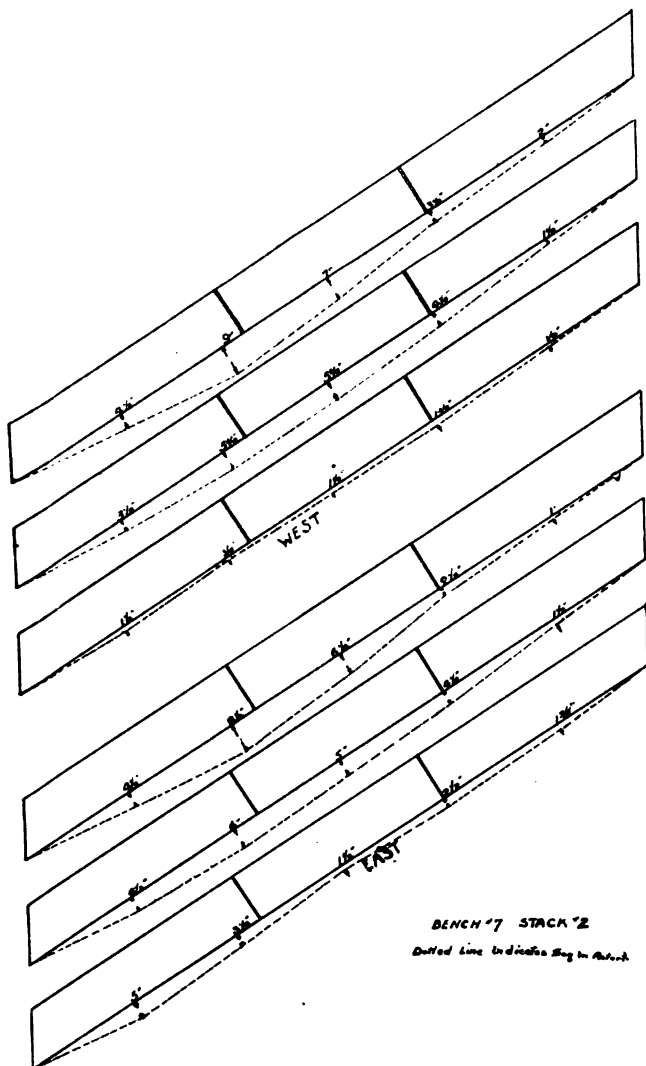


Fig. 10.--Tile in retort at mouth-piece. Page 420.

At no time during the entire operation of house have we been unable to patch leaks confronting us. Not one retort was lost due to falling in, or sagging to a degree that would render it useless.

The first installation of retorts was made in approximately 3 equal lengths, and changed on renewal to 1 short length at bottom end, and 1 long length in center and top. This was done to bring the lower joints closer to the outside, making it easier to patch, especially the lower retorts, due to

it being so close to floor, and unhandy to get long patching rod up retort.



**Fig. 11.—Sagging in Retorts. Page 421.**

Accompanying this paper will be found a diagram, Fig. 11,



showing by dotted lines the sag in the first setting of retorts of bench 7, stack No. 2, the idea being to show the relative shrinkage in setting, a string being stretched through the retort after it was cold, and distances marked every 3 ft.

By referring to duration charts, the life and sag of each retort can be seen. Fig. 12 shows west top retorts of bench 6, stack No. 1; duration over 6 years 10 months. Fig. 13 shows bench 7, stack No. 2, front of bench, lids open; Fig. 14 back or charging end, lids open; and Fig. 15 east top retort looking down from charging end. The photographer did not

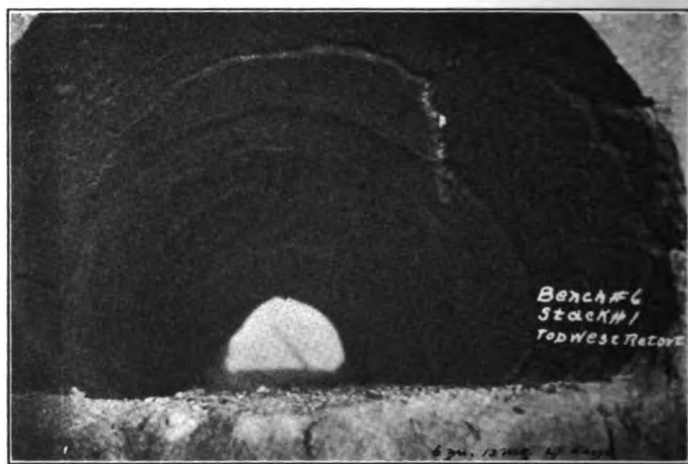


Fig. 12.—Cracks in top retort. Page 422.

get up high enough to show the bottom, but the sag was 8 in. on east side and 9 in. on west side. This bench has a record of more than 10 years duration, and while the sag was more than any of the others, it was serviceable.

We would have trouble in getting a charge of fine slack coal in the retorts, but no trouble with lumpy coal. We usually picked coal for this bench, as stokers find out where the good coal lies. This bench was hot enough before it was let down—March 20, 1914—to thoroughly carbonize 750 lbs. of coal in 5 hours, the coal being free of slack and dust.

There will always be straight and sagged retorts, more or less, and while charges placed and discharged in top and middle retort, like bench 7, stack No. 2, will take more time and work, it is not justifiable to cut out the bench, as the

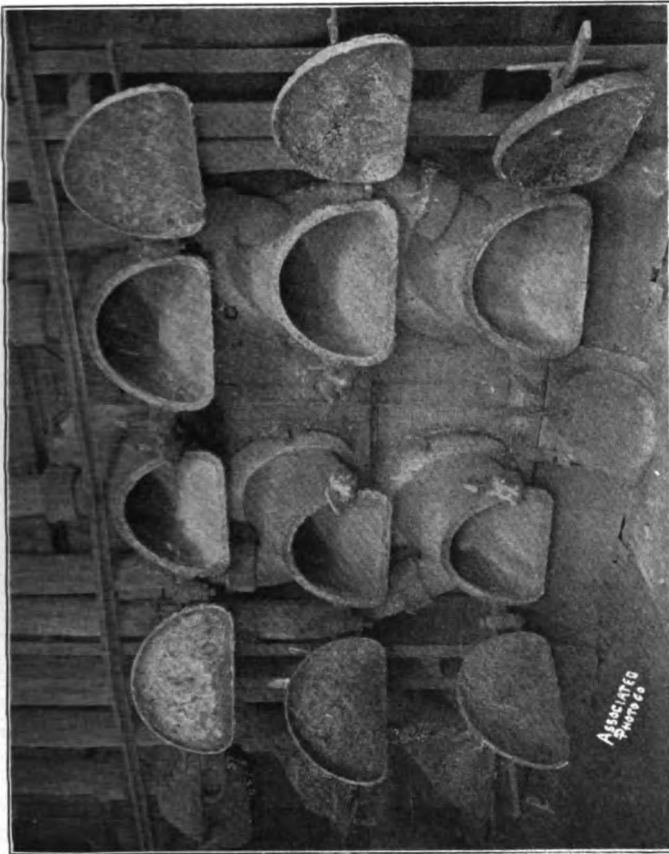


Fig. 13. -- Front of bench. Page 422.

average time for 9 retorts, gang of 4 men, will not exceed 35 minutes, including trying of standpipes, cleaning off, closing and tightening up lids. Some men work faster than others, and 9 retorts have been drawn and charged in 20 minutes. There are exceptional times when a bench becomes

cold, and charges being green, is not ordered run over on longer hours, so that men suffer from the blast of heat above and the poking below.

We have used many different grades of coal, which vary

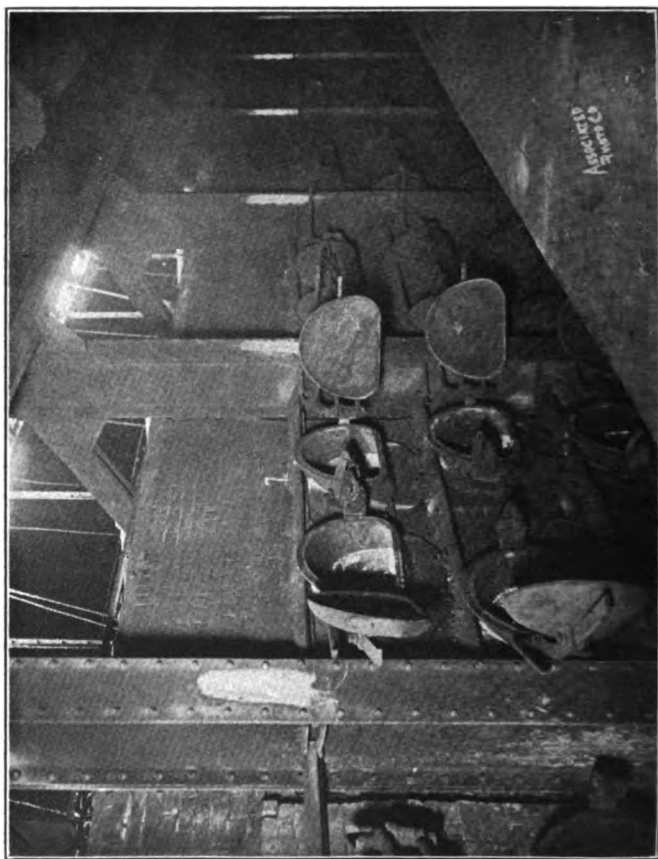


Fig. 14. -- Back of bench. Page 422.

more or less, in regard to charging and discharging coke. When benches are new, we have successfully used 30 per cent. nut and slack, with 70 per cent. run of mine coal, getting uniform charges, but as benches begin to sag, it becomes necessary to discontinue the use of 30 per cent. nut and slack mixed

with mine run because of the trouble encountered with pockets of dead slack, which does not run thick enough to the bottom of the retorts, consequently piling up, and requiring poking down from the top. This increases the work, and stokers will neglect it if not watched.

In charging coal with a large percentage of slack, into retorts sagged as much as 3 in. or more, we have provided a pan made of light sheet iron 4 ft. long, with handle. This pan

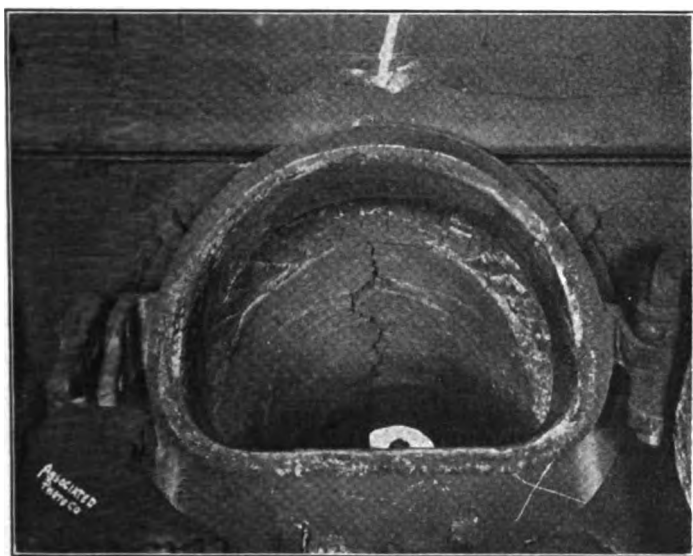


Fig. 15.—Top retort. Page 422.

is placed in mouth of retort, and coal coming out of chute of charger, slides down this sheet iron surface—which becomes polished very soon—and by this method, we have been able to throw good charges to lower end of retort.

The pan is usually withdrawn before the full amount of coal is placed; in most cases, half of the charge being put in with pan, and half without pan.

Pans are very seldom used in bottom retorts, with the regular run of mine coal. Some grades of run of mine coal,

which we received, broke up in transit into very small cubes about the size of a pea, and could be well placed. The best results can be obtained, under all conditions, by crushing lump coal, regulating the degree of fineness at the crusher.

We have noticed at times, that charges after being uniformly placed, would slip to the bottom as much as 2 ft., causing the coal to thicken at the lower end. This we have traced to 2 conditions:

1st. That when very fine slack and dust had been pushed in with the poker from above, it would creep on a cold bench, with retorts of a temperature below normal, and not on a bench some hotter, with the same class of fine coal, indicating that more heat was needed, and

2nd. That when changing from one grade of coal to another, harder and denser, requiring more heat to drive off all of the volatile matter, we would notice a slip even in lumpy coal. When our attention was called to this, we had no difficulty in overcoming it. We would run these particular benches over on longer hours, until heats were brought up, when creeping would cease. No slipping would be noticed in a soft grade of coal, even if heats were below normal. With the exception of slack, there was no grade of coal we have used (in the 13 years) that would not carbonize successfully under our conditions.

*Standpipes.*—Standpipes made of cast iron, 7 in. inside diameter; length of each from bell on mouth-piece to flange on under side of bridge pipe, as follows: top retort, 13 ft. 6 in.; middle retort, 16 ft. 4 in.; bottom retort, 19 ft. 2 in. In running retorts on 4 hours, with 625 lbs., we had trouble with stopped standpipes, attributed to excessive hot weather and high heats of benches.

After charges had been increased to 700 lbs., and then 750 lbs. on 5 and 6 hours, we got along very well with stand-pipes. stokers and foreman being able to attend to them with the ordinary care. Most of our trouble occurred in the summer months, principally due to hot weather, and it became neces-

to put an extra man on each shift during the excessive days, to help out. This usually occurred in July and August.

Stokers were required to run an auger up each pipe on every draw, and to open any pipe showing back pressure between draws. The stand-pipes on bottom retorts were noticed to stop up more than the middle and top ones. They being the longest and closest to the floor, required an auger with a longer handle, which was not as easy for the stokers to manipulate. The stoppage in these pipes was not much more troublesome than the short pipes on the old horizontal retorts, as most of the stoppages in the stand-pipes were close to the mouth-piece.

*Coal Machinery.*—During the course of operating inclines, we have had break-downs of various kinds, none of which, however, held back carbonization of coal in retort case.

Our first break-down was one of the 2-bucket elevators, which elevated coal to a height of 73 ft., with a rated capacity of 10 tons per hour. This elevator fell in a heap, causing the elevation of coal to be suspended until bucket and chains were removed, and duplicate elevator started, holding work back 48 hours.

As no coal is elevated here on Sunday (having 48 hours only) we took this day to straighten the buckets and renew the hoisting chain. The elevator was back in order in 10 hours.

Another break-down was caused by a piece of timber falling out of elevator, and the consequence was the lifting of the iron boot from its anchorage, and carrying it up  $\frac{3}{4}$  the height of tower, before the machinery was stopped. No damage was done, outside of having to replace boot, and tie up.

Renewals on the 2 elevators during the entire operation to wear, were 1 new boot each, 2 sets of sprocket

wheels, 60 ft. of chain, 30 sheet iron buckets, and the usual rebabbitting of boxes.

The receiving conveyor for crusher, conveys coal up on an angle of 40 deg. to a vertical height of 20 ft., in order to drop the coal over screens; separating the large lumps from coal of the required size; the lumps dropping into revolving breaker, thence to crusher, while the finer coal slides down chute to boot, and is elevated as previously mentioned. This receiving conveyor is of the push-plate type; double chains, with sheet-iron flights, shoving coal in a sheet-iron trough at the rate of 60 tons per hour. The chain, flights, sprocket-wheels and journal boxes have not been renewed on this piece of machinery. The trough made of 3/16 in. sheet-iron was replaced 3 times, due to the constant slide of coal wearing it. No break-down was ever encountered on this machine.

*Breaker and Crusher.*—Mine run coal used, usually contained 30 per cent. of the coal already small enough to use in retorts, and provision was made by passing this coal from the breaker and crusher. Only coal larger than 1 in. cube was crushed.

The breaker received the lumps larger than 4 in., and the crusher reduced it to about 3/4 in. Breaker and crusher are of the two roll type, 30 in. in diameter, with teeth. No break-downs were encountered during their period of use, but the crusher rollers had to be renewed within 5 years. Iron bolts and nuts would slip by the men, and would be carried to crusher, breaking off teeth, and allowing 2 in. lumps to pass, which when used in retorts would run down too thick at lower end of retort.

The breaker was not renewed, but the journal boxes were rebabbitted, and shaft turned up. The coal in shed was loaded into cars by negroes, and pushed to receiving conveyor,—sometimes a distance of 100 yards. They labored piece-work; 11 loads per man, approximately 54,000 lbs. as a day's work. Working the men on task work here, gave us plenty of time to make ordinary repairs on machinery, as they were usually

ough in 6 hours,—an ordinary white man would not stand  
: speed.

ne horizontal conveyor, running from elevator tower 120  
across bridge to building, and the 2 over each row of  
hoppers in retort house, are of the push-plate type, with  
center "monobar" chain. These conveyors were not in  
licate, and any break-down would cause the conveying of  
to stop entirely. We have had these conveyors to break  
different ways; the most serious being the bending of nearly  
y flight at right angles on bridge conveyor. These flights  
e made of 6½ in. x 16 in. x ¼ in. sheet-iron, bolted in  
er to flange on monobar chain. There being about 200  
es to take off and straighten, it was quite a task. We lost  
time in getting at this work, having men to take off the  
t flights, and others following up, putting on the straight-  
d flights. This part of the work was done very quickly,  
st of the time being absorbed in straightening the plates.  
er utilizing all of the neighboring blacksmiths, sending  
flights as fast as they were ready, we completed the work  
in 9 hours.

he wear on the conveyor is mostly on the sheet-iron trough,  
ch requires new lining every 3 years. We were always  
vided with duplicate parts of machinery likely to be needed.  
e machines have handled approximately 610,000 tons of  
m and gas coal.

*Charging Machines.*—The charging machines in the retort  
se were made of sheet-iron, supported on 4 wheels,  
ch could be moved from one end of the stack to the other,  
ghing empty approximately 2,500 lbs. Break-downs of  
rgers have happened not more than once a year, such as  
eels becoming loose, and derailing. When this happens  
ing the night, when repair men are not available, a few  
ds of coal will be missed on bench opposite charger. The  
er benches, which are usually not more than 4, are  
rged with shovels. A light chute is placed opposite bench  
e charged, and coal is let out of bin in the usual way into



this chute, directing the coal on charging floor. This coal was charged in retorts by hand, approximating the required amount of coal for each 3 retorts.

Very good charges can be made by placing the coal on the shovel from charging floor. While considerably longer time was required to charge these retorts by hand, we were able to continue along with these retorts during the time charger was being removed to one end out of the way for repairs. There being 2 chargers to each stack, the 1 left was sufficient to do the work.

*Coke Handling Machinery.*—The task of moving coke from the retort house during break-down of hydraulic elevator was of no consequence as in a case of elevator trouble, cars were diverted into yard and unloaded, of course requiring additional help to pile coke up away from car. The method of moving hot coke from retort to quencher, and thence to coke house, required the usual amount of attention by the men to properly protect the cars and to thoroughly quench coke. We have had careless workmen dump hot coke in bin, and on several occasions encountered large fires, in one instance, had to call on the fire department. The coke house being constructed of steel frames, sides and bottom being of cast iron,—outside of renewing half a dozen cast-iron plates and 2 warped beams, the bin has held up very well.

The results shown in Fig. 16 cover a period of 13 years.

Years	Average yield of gas per ton	Average yield of gas per pound.	Average candle-power.	Gallons tar per ton coal carbonized	Ammonia per ton liquid ounces.	Ammonia per ton $\text{NH}_3$	Bech fuel in bushels
1901-02-03.....	9,864	4.93	16.66*	12.17	209.0	4.53	7.1
1904-05-06.....	10,001	5.00	15.62	11.13	237.3	5.13	7.1
1907-08-09-10....	10,109	5.05	15.06	12.02	244.5	5.29	8.1
1911-12-13.....	9,973	4.98	14.13	12.09	232.2	5.03	9.1
Total ave. 13 yrs.	9986.7	4.99	15.36	11.85	230.75	5.002	8.1

\* Gas enriched three-quarter candle-power by oil benches.

Fig. 16.—Operating results. Page 430.

giving the average of each year. These results are based on coal bought by the bushel of 76 lbs. (2,688 cu. in.), and residuals sold. The coal used for carbonizing was determined by adding stock on hand at the first of the year to coal bought, and subtracting the stock of coal on hand at the last of the year.

The residuals made were determined by sales and balance on hand. This was done to get at actual results, as our coal going to retort house was not weighed. We would set portable chargers in retort house by measurement to the different sized charges to be used, and we have found that coal would be spilt on floor, due to slack not going into retorts, and to the different densities of coal, varying in weight.

For the 13 years, the difference between what was used from the report of the retort house foreman, and that bought, would equal 4 per cent.; the greater part of the difference occurring in the latter years, being due to the stokers not getting the full charge load into retorts.

We began weighing coal from shed to retort house in 1911, making out weekly report of results. This worked out very close to the coal bought per year.

The yield of gas given was corrected to 60 deg. temperature, and 30 in. barometer being the standard. Candle-power taken with Sugg D burner and spermaceti candle; gas corrected for temperature and barometer.

The passage of gas from retort house is as follows: 3/10 in. pressure in standpipes, foul main 300 ft. to exhauster, through P. A. tar extractor, then to water tube condenser, thence to standard scrubber and oxide purifiers. During part of 1901, and all of 1902 and 1903, we had 2 oil benches of 2 retorts each, which enriched the gas about  $\frac{3}{4}$  candle-power.

The tar yield being figured from the amount sold, having 2 per cent. water. We have never had any complaint in regard to the quality of tar made here.

Ammonia yield being determined from the quantities of ammoniacal liquor sold, strength of which was made at the

end of each month by distillation test, by outside che Reports were made in liquor ounces per gallon, and this tiplied by 0.02168 gives approximately the ammonia (N made.

*Bench Fuel.*—I have worked out the fuel consumed u benches in bushels per ton of coal carbonized, as our s and all coke used around the plant, were measured quan of 2,688 cu. in. to the bushel. Breeze used in boilers at v not included in determining bench fuel used. Over 75 cent. of the coal carbonized was from the Pittsburgh dis known here as 2nd and 4th pool coal. The balance of used was local coal, and some from the bordering state.

The coke made was estimated by using a coefficient—0. times pounds of coal carbonized equals the bushels of col

The life of retorts as shown on duration sheet was the benches were in actual use. During half of 1911 to M 1914, labor was changed from 12-hour shift to 10 h leaving a gap of 2 hours on each watch, which time is included in life of retorts.

The following results of benches will be a fair ave from 1900 to 1910. I have shown the maximum and mini months of 1902 and 1910; also make per stoker, drawing charging.

#### DECEMBER, 1902. (31 days.)

Make per retort per day. Cu. ft.		Make per bench day (16 bench Cu. ft.
17,448.....	Maximum.....	104,688
15,927....	Minimum .....	95,562
16,640.....	Average.....	99,840

Average make per stoker per day, 99,840 cu. ft.

#### AUGUST, 1902. (31 days.)

Make per retort per day. Cu. ft.		Make per bench day (13 bench Cu. ft.
15,641.....	Maximum.....	93,846
12,090.....	Minimum .....	72,540
13,850.....	Average.....	83,100

Average make per stoker per day, 67,518 cu. ft.

## DECEMBER, 1910. (31 days.)

Make per retort per day. Cu. ft.		Make per bench per day (16 benches). Cu. ft.
15,882.....	Maximum.....	95,292
13,157.....	Minimum .....	78,942
14,300.....	Average.....	85,800
Average make per stoker per day, 91,162 cu. ft.		

## AUGUST, 1910. (31 days.)

Make per retort per day. Cu. ft.		Make per bench per day (14 benches). Cu. ft.
14,952.....	Maximum.....	89,712
12,464.....	Minimum .....	74,784
13,760.....	Average.....	82,560
Average make per stoker per day, 72,240 cu. ft.		

(Mr. Huber read an abstract of his paper.)

THE CHAIRMAN: The paper is open for discussion. We have some written discussions which it would be well to read first, so that the subsequent speakers may include the consideration of these written discussions in their remarks.

MR. B. F. BULLOCK (Fredericksburg, Va.), (Written discussion communicated): Mr. Huber's paper gives us brief, but comprehensive, data concerning the cost of operation in his city of an installation of inclined retorts on a somewhat large scale, and, as I believe I have the honor to be in charge of perhaps the smallest inclined retort plant running successfully for over eight and one-half years, while not bearing directly on the Louisville works described by the author, my little contribution may after all have some interest for the members of the Institute in connection therewith.

The installation at Fredericksburg, Virginia, consisted at first of only two benches of fours, inclined retorts, to which we have recently added a third, owing to the increased demand for gas.

The stack is 25 ft. long and 10 ft. deep, or to make it plainer, the back and front faces of the same are 25 ft. in length, while the width or depth from front to back is only 10 ft. As the engineer was obliged to exercise rigid economy

in the construction of the works, it is safe to say that not as much as one brick has been wasted; so that at the front or discharging side, the benches are only 15 ft. 7 in. above the foundations, while the back or charging end is 21 ft. above. The discharging floor is on the level of the adjoining yard, which is 5 ft. 6 in. above the cellar floor—all the head room we could give under the circumstances—while the charging floor is 14 ft. above the foundations.

The design of the benches is upon the lines of what was once known as the Shoubridge System (Mr. S. Y. Shoubridge, Engineer of the Crystal Palace Station of the South Metropolitan Gas Company, London, England) but modified to suit our conditions. Because of a reason mentioned before, we could not afford to put in an elaborate system for charging the retorts, but the designing engineer for the city originated a simple system, at low cost, but quite effective, which has been in successful operation since the starting of the plant, November 28, 1905.

The benches are heated by half-depth recuperative furnaces, making the cost of fuel somewhat high. The retorts are "D's," 15 in. by 30 in. in section, and about 12 ft. long, "on the slope" having been set at an angle of about 33 degrees.

The charging floor is nearly up to the bottom of the inside of the lower retorts, and these retorts are charged by means of a "Farmer's" coal (dump) buggy, all the coal being first carefully weighed. The upper retorts are charged by the same contrivance, with this difference, that the loaded coal wagon is raised to the required height by a Craig-Ridgeway elevator, then rolled on to a platform wagon, which is carried to the front of a mouthpiece to be charged, and then the contents are dumped into the retorts, as in the case of the lower retorts. I may remark here that though this may seem to be a crude method of charging retorts, the charges are well and evenly distributed, and we have never had any trouble from that source. With but little care and practice, the men soon become proficient in all the work required.

In discharging the retorts, we use a length of  $\frac{1}{2}$ -in. pipe to loosen up the charge. We experienced some of the trouble spoken of by Mr. Huber in reference to the wear on the lower ends of the retorts, caused by the use of the pipe, and in the course of time it became very annoying because of the coke lodging in the worn places.

To remedy this trouble, we scurfed each retort in succession and thoroughly washed out the worn places, to free them from all particles of dust and coke, with a solution of pure fire clay, and then built up with a good patching compound until it was flush with the bottom of the retort.

The material was of almost the same consistency as that used for patching cracks. Special care was used for a few charges in placing the stopper, and a bushel of coke dumped into each retort before charging, and a hook was used to start the charges, not putting the rod into the retort until after about 2 ft. of the charge had been removed. By this method the patches would last until the next period of scurfing.

Since our retorts have been renewed, we have used both the coke and the hook for starting the charges, and after 12 months operation, the retorts show no sign of wear.

We have had to renew the retorts three times since the original construction, and the whole setting was renewed last year, at which time we installed an additional bench.

We would undoubtedly have gotten a longer life out of the retorts, except for the fact that we were obliged to operate both benches for about 10 months during the year, and having no reserve, could not afford to take chances, but now that we have the additional bench we will get all the life possible out of the retorts before renewing.

Our method of scurfing consists of drawing the charge, leaving the bottom door open about an inch, the top door being left wide open. A plate with a hole about 4 in. square in the center is hung on the upper mouthpiece; this prevents the upper door from becoming warped.

The weight of coal per charge depends entirely upon the

amount of gas needed, but I have always obtained the best results by making the charges large and the time of carbonization long. We never use less than 400 lb. per retort in any length of time, and if this amount of coal makes more gas than we need, we lengthen the duration of the charge and fix the weight of coal to correspond.

Our best run for a single bench was 51,200 cubic feet, or 12,800 cubic feet per mouthpiece, in 24 hours, with a yield of 4.85 cubic feet per pound, working 6 hour charges.

We have never been bothered with stopped standpipes, having only had two since we started operation, and these were cleared with the ordinary auger in a few minutes.

Our carbonizing results cannot well be compared with those of other plants using inclines, as we would show considerably more furnace fuel per ton of coal carbonized, for we have never been able to run to capacity.

Our coke is of very good quality due to the fact of the long duration of charges, and our yield of gas has varied according to the quality of coal used. At the present time we have no difficulty in getting considerably over 5 cubic feet per pound running 8 hour charges, the coal being good.

We were forced to renew the recuperators because of the seams opening, short circuiting the secondary air and killing the draught. In the original setting, the tile in the recuperators were set with flat joints, but in the rebuilding, all joints were made tongued and grooved.

We have always made a straight coal gas, although for a short time we used a cannel coal enricher, and on one occasion used, with very good results, kerosene oil in connection with the coal, to tide us over an extremely hard pull, due to a break down in the electric light plant.

MR. W. E. STEINWEDELL (Cleveland): Written discussion communicated.) On account of the shrinkage and settlement of clay retorts and clay setting blocks, installations of inclined retorts were not entirely satisfactory until 1911, when inclined

sectional silica retorts, each 15 ft. long, and silica block settings, were installed in two benches at Mobile, Alabama.

These benches gave such excellent results that three more benches were added and later three more, making eight benches of inclined sixes in all.

Installations of inclined sectional silica retorts, with silica block settings, have also been placed in gas works in the following cities:

Jacksonville, Florida.....	9 benches
Decatur, Illinois.....	6 benches
Benton Harbor, Michigan.....	4 benches
Charlotte, North Carolina.....	4 benches
San Juan, Porto Rico.....	4 benches
Laurium, Michigan.....	2 benches
Biloxi, Mississippi.....	2 benches

These benches with retorts 15 ft. long can carbonize 900 lb. of coal per retort in four hours, but the results are not as satisfactory as when 900 lb. are charged every six hours, and the latter is the common practice.

The actual results in an installation of silica retorts as compared with those obtained in the clay retorts at Louisville are as follows:

	Results clay materials 18' 0" retorts	Results silica materials 15' 0" retorts
Net tons of coal handled per man per day in retort house.....	9.28	10.8
Cubic feet of gas made per bench per day.....	99,840.0	114,000.0
Cubic feet of gas made per stoker per day.....	99,840.0	114,000.0
Cubic feet of gas made per retort per day.....	11,640.0	19,000.0
Cubic feet of gas made per pound of coal carbonized	4.99	5.28
Candle-power.....	15.36	15.5
B. t. u. per cubic foot.....	--	592.0
Gallons tar per ton of coal.....	11.85	13.0
Pounds of ammonia per ton of coal.....	5.002	4.3
Pounds of coke for bench fuel per ton of coal....	326.0	240.0

Candle-power taken with Suggs improved argand burner.

Gas made per pound of coal carbonized in silica retorts is averaged for four years and is based on actual inventory figures.

The above ammonia yield in this installation of silica re-



torts is low, due to insufficient scrubbing machinery and the temperature of cooling water not being below 68° F. the year round.

Results yield, candle-power and heating value obtained with silica retorts and settings over a period of three months, were as follows:

Average cubic feet gas made per pound coal .....	5.38
Average candle-power of gas made.....	16.5
Average B. t. u. per cubic foot .....	609.0

Mr. Huber is to be congratulated on the excellent results obtained with the Louisville installation and the careful records of installations, operation and maintenance which he is now able to present in so thorough a manner.

THE CHAIRMAN: May we hear from Mr. Mueller?

MR. M. E. MUELLER (Astoria, Long Island, N. Y.): At Astoria, we have an installation of inclined retorts which differ somewhat from those described in Mr. Huber's paper and in the written discussions which have been submitted, mainly in the fact that the retorts are longer, 20 ft. long instead of 15 to 18 ft. long. These retorts are set on an angle of 33 degrees, and we normally charge 1,000 lbs. of coal every six hours. On a test, we have charged as much as 1,900 lbs. of coal into a retort, but that could not be carried out in operating conditions. That was an inclined retort, charged as full as possible, and under those conditions, it would run similarly to a vertical retort. It was very difficult to get the coke out of the retort in that case.

One of the principal difficulties which we have had with inclined retorts is getting coal into the retort. There are several distinct causes which bring about this trouble. One of them is that the bottom of the retort gets rough and that coal will not run into the retort. Another trouble we have had, is that where the coal first strikes the retort, it forms a depression in the retort, which tends to hold the coal back. We have overcome this to a certain extent by changing the angle of the charging chutes, so that the coal will not strike the bottom of

the retort at such a sharp angle. But the principal trouble that we have found in getting coal into the retorts has been that the lower section of our retort—our retorts being built in two sections—have in many cases come up at the joint, forming an offset which quite effectually prevents the coal getting to the bottom of the retort. We have used pans, such as Mr. Huber mentions in his paper, to help out this trouble, and they are quite effective, but there is the greatest difficulty in getting the men to use them.

We have also had the same trouble that Mr. Huber illustrates in his paper on page 412, of the walls of the oxide flue caving in, and we believe we have overcome that trouble in the same way that Mr. Huber has, by putting in suitable braces. Unless our recuperators are kept in good condition and carefully watched, it is a difficult matter to keep the proper heats in the benches. It takes a great deal of attention to see that the recuperators are kept tight. Another difficulty is to get a uniform heat throughout the entire length of the retort. Our retorts are longer than any of these which have been mentioned, and probably the longer the retort, the more difficult it is to get a uniform heat throughout. In the design of our benches, this is supposed to be accomplished by shifting tile in the oxide flue, but although this works very satisfactorily in a new bench when the tiles shift easily, in an old bench, when the blocks begin to sag and patching cement drops down into the flue, these tiles become cemented to the wall and it is very laborious work shifting these tiles. We have tried to obtain an even distribution of the heat by putting in the upper part of the flue, between the top retorts, tile with small openings, we have found it necessary to resort to the use of shifting operate very satisfactorily, the heat being very uniform from end to end. In other benches, with tile of the same size openings, we have found it necessary to resort to the use of shifting tile in the oxide flue to prevent overheating in some parts of the retort.

We have also at times had trouble with the front wall

of a bench coming out, due to the outward thrust of the retort, and we are at present building this wall heavier, and hope to overcome the difficulty in that way. Our greatest difficulty has been with stopped standpipes. There is no doubt but what some of this trouble is due to the neglect of the stokers, but not by any means all of this. Small charges, uneven charges, or high local heats in any part of the retort, will all bring about stopped standpipes. A new bench will run for months without a sign of a stopped pipe, but as soon as anything goes wrong with the bench, stopped pipes will occur. I believe that 90 per cent. of all defects in an inclined bench will sooner or later show up in the form of a stopped standpipes. There is one other point I should like to call attention to, and that is, the matter of scurfing inclined retorts. Most of the carbon in our inclines, at any rate, collects on the roof of the retort near the lower mouth pieces. When this carbon first collects it is very soft and can be scraped off. We have found that by scraping the retort once or twice a day, scraping off this carbon at the lower end of the retort, it is possible to keep the retort clean for a much longer time. It also prevents the stoppage of the gas in the retort, which frequently happens if a heavy carbon accumulates on the roof of the retort, causing leakage of the upper mouthpiece.

MR. F. E. DRAKE (Lynn, Mass.): I think Mr. Huber deserves a great deal of credit and a hearty vote of thanks for the frank statement of facts and the complete paper which he has presented here to-day.

There are several questions which I wish to ask. First: Are not his figures all in net tons? I should judge, from figuring it out myself, that they were. Also, I would like to ask Mr. Huber where he obtained the factor 0.02168 which is given on page 432 and which he uses in transferring his ammonia from ounce gallons to pounds?

After having read this excellent paper, I thought it might be of interest to the members of the Institute to know what we were doing at Lynn, so with that end in view, I com-

piled a table which gives the actual operating results from October 1, 1913, to October 1, 1914. These results are representative of what has been done at Lynn since the inclines were first fired up in 1903. We, of course, have run the whole gamut of good, bad and indifferent operation, as most gas works have, and at times have obtained as high as 20,000 per retort, and at others as low as 14,000, but the results for the past year are fair averages of what can be and has been done at Lynn.

The Lynn installation consists of ten benches of nines in two stacks of five each. The retorts are 18 ft. long; 16 in. x 23 in. top, and 16 in. x 25 in. bottom. The furnaces are of the outside regenerative type, 3 ft. 0 in. x 4 ft. 7½ in. x 7 ft. 0 in. Under four of the benches, we have rebuilt the furnaces, returning the flue gases under the grates, and making a much larger furnace, they being 5 ft. x 5 ft. x 7 ft. 2 in. The original benches were of imported German material, German made, and we obtained a life of from four to five years, at the end of that time renewing the retorts from the lower retort saddle block up. Last year we renewed two benches from the discharging floor up, using silica sectional retorts and doing away with all shifting tile, which was quite a radical departure from the old style bench and which apparently is a long step forward in the right direction, for it simplifies to a wonderful extent the bench operation. One other radical change was made in this renewal; the retort, instead of being tapered, was made straight, being 16 in. x 25 in. the entire length. These benches have been in operation since last May and we are obtaining good results, although in the next refilling we are making changes which, from the experience we have gained with the present setting, we believe will still further improve our results.

In regard to the table which is appended, I would like to state that all gas is corrected for temperature, all coal is in gross tons, and the ammonia results are taken directly from our sales to the chemical company who purchase our entire con-

OPERATING RESULTS, OCTOBER 1, 1913, TO OCTOBER 1, 1914.  
LYNN GAS & ELECTRIC CO.

Month	Gas made corrected	Pounds coal carbonized	Gross tons coal carbonized	Yield per pound	Candle-power	Candle-feet	Average pounds coal per retort	Retort yield	Make per gross ton	Number of benches	Make per bench 24 hours	Make per man per 24 hours	B. t. u.
1913													
October ..	36,519,595	7,051,000	3,148	5.18	16.67	86.61	829	17,174	11,601	8.0	147,256	53,548	
November	35,148,006	6,762,680	3,019	5.20	16.78	87.42	851	17,718	11,642	8.0	146,450	53,254	
December	36,966,470	7,199,070	3,214	5.13	16.84	86.22	847	17,408	11,501	8.0	149,058	54,203	
1914													
January ..	37,532,675	7,140,480	3,188	5.26	16.49	86.56	857	18,018	11,773	8.0	151,341	55,033	
February ..	34,528,859	6,527,370	2,914	5.29	16.18	85.55	862	18,240	11,849	8.0	154,146	56,033	
March.....	34,330,588	6,637,750	2,963	5.17	16.62	85.83	871	18,040	11,886	7.0	158,205	55,372	
April .....	31,959,820	6,254,530	2,792	5.11	16.56	84.63	867	17,531	11,447	7.0	152,189	53,266	
May .....	42,559,310	8,117,190	3,624	5.24	16.28	85.74	889	18,666	11,743	8.61	159,451	57,611	591
June .....	42,556,550	8,192,960	3,658	5.19	16.58	86.58	877	18,227	11,634	9.0	157,617	56,742	591
July .....	43,622,854	8,430,640	3,764	5.17	16.63	86.19	875	18,114	11,589	9.0	156,354	56,287	614
August....	44,000,090	8,421,080	3,760	5.22	16.60	86.77	874	18,276	11,702	9.0	157,706	56,774	620
September	42,810,432	8,223,780	3,671	5.20	16.90	87.88	884	18,413	11,661	9.0	158,554	57,080	611
Total .....	462,535,139	88,959,420	39,715		199.13		10,373						609
Average ..				5.20	16.59	86.27	864	18,004	11,644		154,178	55,527	

Average gallons tar per gross tons coal carbonized for year = 12.0  
Average pounds  $\text{NH}_3$  per gross tons coal carbonized for year = 4.52

centrate. The candle-power is obtained on a 100 in. closed bar photometer with an Argand D burner.

Regarding the "Make per man per 24 hours," I wish to call your attention to the fact that our union stokers work but eight hours per day. When we run nine benches, we must have eight men per shift; with eight benches, seven men per shift, and when we get down to seven benches, we must have six men per shift, and have extra men from outside to dump the tar drums. In my figures, I have also included the retort house foreman.

The table on page 442 gives the results from October 1, 1913, to October 1, 1914.

**THE CHAIRMAN:** We are indebted to Mr. Drake for his complete figures, constituting the statement of a year's operation.

**MR. J. H. TAUSSIG (Philadelphia):** I have never run an inclined bench, but one reading this paper is very much impressed with two or three things. One of them is the freedom from break downs in this plant. To have one break down a year, and that does not seriously impair the operation of the plant, is, I think, an argument for a plant equipped as this one is. Another thing is the rather long life of retorts. One would think though, that a mistake was made, as in many other coal gas plants, in running retorts beyond their economical life. I have seen many plants in which the superintendents wanted to get a certain life out of their retorts despite the fact that they were losing maybe 10 to 15 per cent. of the gas, and patching the retorts almost every draw. I think this is very poor economy. One would think from looking at the pictures in the paper that this plant, although it had very excellent results for a long period, would have improved these results considerably had they shut the benches down and repaired them before they were in such bad condition.

**MR. J. A. PERRY (Philadelphia):** I should like to know, with the silica retort in use, was there any noticeable reduction in furnace fuel per ton of coal carbonized? And also was

there any increase in gas made per retort or bench per day over the clay retorts?

MR. R. LINDSAY (New Bedford, Mass.): I should like to know whether the coal was measured or weighed before going into the retorts?

THE CHAIRMAN: Mr. Huber, will you close the discussion?

MR. HUBER: The trouble that Mr. Mueller has had coincides very closely with what we have had at Louisville. A question was asked about net ton or gross ton. It is 2,000 pounds per ton. There was a question asked in regard to the coefficient in arriving at the quantity of ammonia. That was the coefficient we have been using, and I am not able to say whether it is correct or not, but I feel it is approximately. In regards to measurement of coal, it was measured quantities in portable charges daily, but in our weekly result from 1911, coal was weighed.

Measurements of coal were in bushels, 2,688 cubic inches and this multiplied by 76 lbs.; that was explained in the paper.

MR. DRAKE: Regarding increased results with silica retorts, I would say that we have only been operating them since last May, so we cannot say just what we are going to get for life, but we feel that we are able to run rather higher heats with the silica retorts and get somewhat better results. They are in a stack with ten other benches, so we cannot tell what each individual bench is doing. Regarding furnace fuel, from rough tests which we have made, we feel that we are getting slightly better results than with our old type generator, some 3 or 4 lbs. better, I should say.

THE CHAIRMAN: We have a written discussion from Mr. Egner. I am very sorry he is not here to give an abstract of it himself. It reinforces some of the points that have already been set forth, and will be included in the discussion.

MR. FREDERICK EGNER (Washington, D. C.) (Written discussion communicated): Mr. Huber deserves commendation for the careful record he has kept by means of his "duration

charts," photographs, and other helps to illustrate the life of his benches. These graphic descriptions are well worth consideration on the part of those gas engineers who think and say that our American material is not as good as the German or English refractories. Mr. Huber, in his paper, demonstrates that American fire-clay material, properly made or mixed in the first place, is as good as any that ever came across the Atlantic Ocean. The material which entered into the construction of the Louisville benches came from St. Louis was, as I know, properly weathered when first dug from the mines, was given the proper admixture of fire-sand, thoroughly treated in the mills, and such material when made up into retorts, brick or tile, by experienced men, is bound to give results such as Mr. Huber has shown us. I did not mention St. Louis material to create the impression that it is the best, or better than any other, because during the many years of my active connection with coal and water gas works I have found Pittsburgh, New Jersey, and a number of other American fire-clay producing localities from which unsurpassed refractory articles were and are still turned out. "It is all in the mix," as one of the foremost fire-clay men once remarked to me.

The really most important thing brought out by Mr. Huber in his paper, strikes me to be the fine showing for American fire-clay material which he has now brought before us. I visited the Louisville gas works several times while these benches were getting their first heating up, and I fairly trembled more than once when observing here and there a bench grossly neglected on part of the firemen, who had let the furnace go nearly empty, with primary and secondary air slides wide open, or even lying upon the cellar floor. I am therefore greatly pleased to learn from the paper under discussion that these benches lasted on an average of five and one-half years, an unusually long period for coal gas benches anywhere, and of whatever material they may be made. These benches were given intelligent and careful management, else results shown could not have been obtained.



As the archives of the American Gas Institute are not overburdened with references concerning the inclined retort system, it may be permissible, and even desirable, for the sake of amplifying our published PROCEEDINGS, to go a little further into the subject of the operation of inclined retorts than Mr. Huber has done in his good paper. Therefore, I submit in connection with the tables furnished by Mr. Huber, certain data furnished me in a signed statement by Mr. S. Y. Shoubridge, at present the Engineer-Manager of the Crystal Palace District gas works of the South Metropolitan Gas Company, of London, England, but at that time in a like capacity at Salford. And I believe that, although the results recorded by Mr. Shoubridge date back 17 years, a comparison with Mr. Huber's figures will not be uninteresting at this time, when we remember the relationship of design, as one might designate the respective benches, though the results of one were "Made in England," and the other at Louisville, Kentucky, United States of America.

The Salford benches had been only two years in operation when I saw them (April and May, 1897), and when Mr. Shoubridge favored me with a copy of his carbonizing figures, and I may add now, that in later years the results were much more favorable than those quoted herewith. Because of the above reasons, I shall use only those figures of Mr. Huber's which refer to about the same space of time, *vis.*, one year (See pp. 432 and 433 of the paper), when the retorts were new and supposedly at their best at Louisville, that is, in the year 1902.

Mr. Huber states on page 430, that during the years 1901-02-03, they required 7.79 bushels (2,688 cubic inches per bushel) of coke to carbonize one ton of coal, which, in other words, means that they used about 20 per cent. of the coke made, and when the European standard is employed, it means that they did their work with 13.63 lbs. of coke per 100 lbs. of coal carbonized, which I think was very good work. At Salford they used 16 lbs. of coke per 100 lbs. of coal, but the coke is de-

SALFORD, 1897.	LOUISVILLE, 1902
Weight per charge ..... 672 lb.	Weight of charge... 700 to 750 lb.
Duration of charges..... 6 hr. Could carbonize above weight coal easily in 4 hr., but thinks "It is better for the settings to work with less heat. We can, and occasionally do, vary both the weight of charge and time of carbonizing." (Shoubridge)	Duration of charges .... 5 to 6 hr. Had run on 4-hr. charges, but did better with 5 and 6 hr. (pp. 410 and 426) "The working basis being 5 hr. Charges were changed according to grade of coal received." (Huber)
Average yield of gas per lb..... ..... 4.54 cu. ft.	Average yield of gas per lb..... ..... 4.93 cu. ft.
Candle-power not stated.  But in England they rarely make over 15.00 candle gas, and in many cases even less. (F. E.)	With assistance of oil ..... ..... 16.66 c-p. (p. 430) But in later years without oil, from 15.62 down to 14.13 c-p. (I wonder if the volume of gas from the oil was credited to the inclined benches? F. E.)
Make per retort in 24 hr. Average, 12,230 cu. ft. (In later years made 18,345 cu. ft. per retort in 24 hr.)	Make per retort in 24 hr. Average of highest and lowest in year 1902 (p. 432) 15,245 cu. ft. Highest, Dec., 1902, was 17,448 cu. ft.
Average per bench.. 85,610 cu. ft. Highest, later years, 138,415 cu. ft.	Same average..... 91,470 cu. ft. Highest, Dec., 1892, 104,688 cu. ft.
Made per man employed in the retort house per day, 76,209 cu. ft. The day was divided into three shifts of 8 hr. each.	Made per "stoker" only, per day averaging for the year 1902, 91,480 cu. ft., though "highest" given by Mr. Huber is 99,840 and "lowest" 67,518 cu. ft. (p. 432). Two shifts only. (p. 411).

scribed by Mr. Shoubridge in his statement of that remote date, as being of poor quality, whereas that made from the second and fourth pool (Youghioghenny) gas coal of which Mr. Huber writes that they used 75 per cent. (p. 432) is usually unsurpassed as to quality. I thought that by now the coal named had been exhausted, but the Penn and Westmoreland and coals mined in that section are also good, and the very

best coal that I ever had experience with came from somewhere in Kentucky.

I cannot agree with Mr. Huber where, on p. 429, he says of his negro coal men, "An ordinary white man would not stand their speed." I dare say that this is true of Louisville, Ky., but I have never yet seen a negro—with a few rare exceptions—who could do as much hard work in a day's labor as a suitable white man could, either in a retort house or in the ditch with the street main and service gangs. By suitable," I mean a man fitted to do the work required.

It would have been interesting if Mr. Huber had given a few comparative figures as to results between their former horizontal retort benches and the inclines. It goes without saying that had the inclines not done better, they would not have continued with them for nearly 14 years, or until the bringing in of natural gas caused the shutting down of the artificial gas works. Hence, I think I may be excusable if I submit some more of Mr. S. Y. Shoubridge's statements bearing on the relation between horizontal and inclined benches, as he had both at the Salford works. I beg leave once more to call your attention to the fact that while the Salford data was obtained 17 years ago, the comparative values are as useful to-day as when first recorded, although the performances of inclined, as well as horizontal retort, benches has been somewhat improved since then everywhere. Mr. Shoubridge's statement of 1897 is given on page 449.

"The weight of charges and duration of charge was the same for both inclined and horizontal retorts, *viz*: (At that time) 6-cwts. (or 672 lbs.) per charge every six hours.

"The temperature of the retorts can easily be adjusted to carbonize 6-cwts. in four hours, but it is found better for the setting to work at less heat." The fuel used in both the inclined and horizontal retorts is the same in quantity and equality, *viz*.: 16 lbs. of coke of a very poor quality, per 100 lbs. coal carbonized.

1—Cost per setting of inclined retorts: (I understand that Mr. S. had changed to 20-ft. long retorts later and no doubt these figures referred to the latter. F. E.)	Cost per setting of 7 retorts 20 and (?) long on slope £924 (\$4,499.88). This includes all brickwork, retorts, ironwork, proportion of the charging, drawing coke floors, chimney, overhead storehoppers, gas engine, coal-breaker, elevator and conveyors. F. E.
2—Do. of horizontal retorts: (The £ or "pound sterling" is \$4.87. F. E.)	Cost per setting of 7 retorts 20 ft. long of same section as the inclined retorts—£868 (\$4,227.16), including all retorts, brickwork, and ironwork, and proportion of charging and coke floors. F. E.
3—Space occupied by a setting or bench of inclined retorts.	11 ft., 8 in. $\times$ 17 ft., 0 in. "D's" retorts 20 in. $\times$ 16 in. at top to 22 in. $\times$ 16 in. at bottom; 20 ft., 0 in. long on "slope." (I believe the figure 20 ft., 0 in., is an error. F. E.)
4—Space occupied by horizontal retort 20 ft. long.	"D's" 22 in. $\times$ 16 in. $\times$ 20 ft. 11 ft., 8 in. $\times$ 20 ft., 0 in. throughout.

"There is no saving by inclined retorts under any head, but only in the charging and drawing."

Being asked how the inclines compared with the horizontal retorts in cost for repairs, he replied: "Have not needed repairs as yet. (After two years in operation.) Am strongly of opinion the retorts will last longer than 'horizontal,' and the cost of repairs will be less," which Mr. Huber seems to have demonstrated to have been the case in his experience. If not, he might now tell us about that. The writer, as some of you know, had been at one time an ardent advocate of the inclined retort system, and is naturally greatly pleased to learn from Mr. Huber's paper that the stand he took nearly 25 years ago on that subject turned out so well, at least in Louisville, Kentucky.

There are other places, probably, where the inclined retorts were successful in the United States, for they were universally successful at a great many works in Europe and Tokio, Japan,

but there is one small plant of inclined retorts which he knows was and still is successful, *viz.*: at Fredericksburg, Virginia.

Mr. Huber has explained the cause of coal slipping in the retorts very cleverly, and it is a pity we did not have such an explanation a quarter of a century ago, when the coal slipping in the retorts was frequently made a fetching argument against the adoption of the inclined system. Now, when "horizontals and inclines" may be considered to be in the same class with the writer perhaps, *viz.*: "back-numbers," it seems almost a waste of time to read and discuss a paper on that subject, but having been invited to participate, I did what I could think of to help to "keep the ball rolling." In view of what is now accomplished with the vertical retorts and chamber oven or "By-product Coke Oven" systems of various designs, it appears to me that the "inclines" are hopelessly outclassed as desirable for large gas works, but for smaller works, they may still be worth while thinking about when rebuilding or enlarging must be considered.

MR. E. L. SPENCER (New York): I move that a vote of thanks be extended to Mr. Huber for his very interesting paper.

The motion was seconded and carried.

THE CHAIRMAN: The next scheduled business is the Report of the Committee on Progress in Carbonization Methods, by Mr. E. L. Spencer, Chairman, of New York.

## REPORT OF THE COMMITTEE ON PROGRESS IN CARBONIZATION METHODS.

The general business depression which has prevailed throughout the country during the past year has been felt to a considerable extent by those interested in the design and construction of carbonizing apparatus, and the number of plants contracted for during that period has been much below the normal. However, numerous installations which were under construction at the time of the last Institute meeting, have

been placed in operation, and several very interesting designs of bench details have been worked out, and are submitted in the following pages.

There is no doubt that silica material for bench construction is finding many converts among gas engineers. This material has been used successfully in numerous horizontal retort houses. A successful application of it to inclined benches has recently been made at Lynn, Mass., where 4 benches of 9's have been rebuilt with silica setting blocks and sectional silica retorts. These retorts have parallel sides, instead of being tapered as is usual with inclines.

The builders of the well-known plant at Worcester, Mass., report that they are engaged in the erection of several installations of horizontals which contain novel features. These plants consist of silica benches of 16 retorts each. They are equipped with standpipes of rectangular section, which are located at the partition walls of the benches and act as front buckstays. To each standpipe is connected 16 retorts. The hydraulic main is in the cellar. The stoking machines are equipped with automatic devices for weighing the retort charges and also the fuel fed to the generators. Further details regarding these installations are to be published at a later date.

The installations of horizontals at Madison, Salem and Philadelphia, which were mentioned in last year's report, have since been placed in successful operation, and a similar plant is being erected at Toledo by the same contractors. All these plants are constructed of silica material, are machine stoked and are equipped with a  $\text{CO}_2$  return system. They are further described and illustrated in the following pages.

During the past year, improved charging and discharging machines of the DeBrouwer type have been installed at Salem and St. Louis. These machines are of the projector type, and are equipped with weighing hoppers and automatic feeding rolls. The speed of the belt is automatically slowed down, as

the retort is filled. At the Salem plant both the charger and discharger are mounted on the same carriage, and this type of apparatus is economically used in a retort house of 600,000 cu. ft. daily capacity.

In this report will be found illustrations of manual charging apparatus suitable for small retort houses.

There is also found a description of the Congdon scrubber standpipe as used at Atlanta, together with an account of various attempts which have been made in past years to eliminate standpipe trouble.

There has recently been placed on the market a producer as illustrated, which is stated to be capable of operating on bituminous coal or lignite, and which was designed to supply producer gas for heating carbonizing apparatus.

Vertical benches of the Woodall-Duckham type, which were under construction at the time of the last Institute meeting, have been placed in operation in the following cities: Holyoke, Mass.; Derby, Conn.; Brockton, Mass., and Schenectady, N. Y. The largest of these is the Schenectady plant, with a capacity of 1,250,000 cu. ft. per day. The retorts of the Derby plant are made of silica.

During the past year, vertical benches of the Glover-West type have been placed in operation at Fitchburg, Mass., and Pawtucket, R. I. Both installations were described in last year's report. Installations of this type of benches are under construction at Portland, Me., and Springfield, Mass. The Springfield plant will have an ultimate capacity of 1,500,000 cu. ft. daily, the others being smaller.

Vertical benches of the intermittent type have been erected at Fall River, Mass., and Hartford, Conn., each installation having a capacity of 1,050,000 cu. ft. per day.

Two interesting installations of small gas ovens have recently been erected in Europe. Some operating figures and a description of the plant at Innsbruck, Austria, which is of this nature, are appended.

is proposed to erect this type of plant for installations having a capacity of from 500,000 to 1,000,000 cu. ft. per day.

A large coke oven plant is being erected at St. Louis, Mo., which is so designed that the ovens can be converted to gas as if desired. It is expected that this plant will be in operation during the spring of 1915.

It has been suggested to the Committee that a study of the proper preparation of bituminous coal for gas making is a subject which would be of interest to those operating carbonizing plants. In this connection may be quoted a letter from a well-known engineer who is engaged with a large coke oven company:

This subject of the elimination of impurities from coal before carbonization is one of very considerable importance in the coke oven industry, where a high grade of metallurgical coke is of prime importance. Unquestionably it is of some importance also to coal gas plants, and will be of increasing importance as the cost of the purest and best gas coals increases relatively to the cost of coals running somewhat higher in sulphur and ash. At most of our larger plants, we have operated Bradford breakers for several years. This provides a cheap method of breaking the coal and does eliminate the large masses of pyrites and other material which are broken with greater difficulty than the pure coal. The reduction in sulphur and ash by the use of this apparatus is comparatively slight. As the sulphur eliminated, however, is principally in the large masses, we do secure a coke, the sulphur content in which is very much more uniform. If these large masses of pyrites pass through the entire operation, different samples of coke taken from different parts of the same oven may vary noticeably in the percentage of sulphur, which may give rise to controversies between producers and consumers. One of the great advantages of the Bradford breaker in practice is that it throws out pieces of iron and steel, which, if allowed to get into the gasifiers, may cause serious damage. We have used washed coal at two of our plants, but this process does not entirely



reduce both sulphur and ash. It results in making the use of coals which, without this preliminary treatment would be ruled out. As the percentage of ash in a fuel greatly affects the market value, I believe that in cases washed coal might be of advantage in gas works especially where vertical retorts are used."

The problem of disposing of the coke is a vital one in the coal gas industry, and attention is called to Bulletin No. 60, published by the University of Illinois, which describes an elaborate series of evaporative tests of coke and various fuels in house heating boilers.

Bulletin No. 60, published by the same institution is titled "The Coking of Coal at Low Temperatures", and contains much food for thought, and will surely repay the study of gas engineers.

The Committee is of the opinion that much good may be derived from formulating in detail a standard method of operating gas works, and we respectfully suggest that the Association take steps to supplement the work which several years ago was done in this direction.

E. L. SPENCER, *Chairman*  
 G. A. BALZ,  
 H. A. CARPENTER,  
 R. C. CONGDON,  
 J. S. DEHART,  
 C. J. RAMSBURG,  
 D. R. RUSSELL,  
 HERMAN RUSSELL,  
 E. Y. SAYER,  
 W. E. STEINWEDELL,  
 J. H. TAUSSIG,  
 H. L. UNDERHILL.

## REPORT OF THE GAS MACHINERY COMPANY.

*By W. E. Steinwedell.*

The superiority of benches with silica retorts and settings has been so conclusively demonstrated that the advisability of using them is now conceded by all. Silica retorts must, however, not be confused with those made of silicious materials, which contain only about 85 per cent. of silica, and which are frequently inferior to clay retorts. Silica material should be homogeneous.

Silica retorts, with silica setting blocks to support them, are essential for modern and economical operating conditions, as they can withstand high temperatures for several years, do not shrink nor change shape, and produce coal gas at less cost than clay retorts. They have the following advantages over clay retorts and settings:

1. Greater Durability. Silica materials are not affected by high heats; consequently, refilling of arches is less frequent, and fewer benches are required for reserve.
2. Less Bench Fuel. Silica has 25 per cent. greater heat conductivity, higher heats can be used, and less carbon adheres to the retorts.
3. Greater Capacity per retort per day. The higher heats permit heavier charges and shorter time of carbonization; therefore, fewer benches are required to produce a given quantity of gas.
4. Increased Strength. Silica maintains uniform strength at working temperatures; consequently, less repairs are required.
5. Retort Alignment. Retorts neither sag nor bulge, as silica materials do not shrink nor soften under high temperatures. This is especially important where charging or drawing machines are used.
6. Less Scurfing to remove carbon from the retorts. Car-

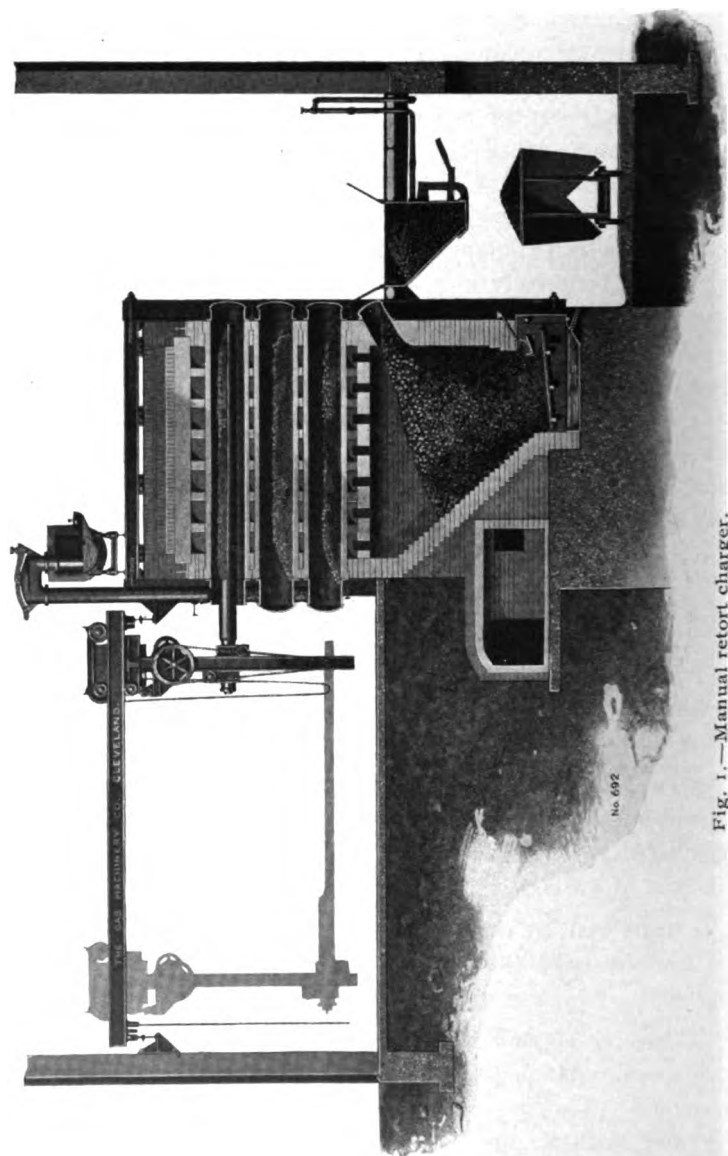


Fig. 1.—Manual retort charger.

does not readily adhere to silica; therefore, retorts are frequently out of commission.

number of additional installations of benches with horizontal through retorts about 11 ft. 6 in. long, have been made in the past year, and the coke is discharged by a hand

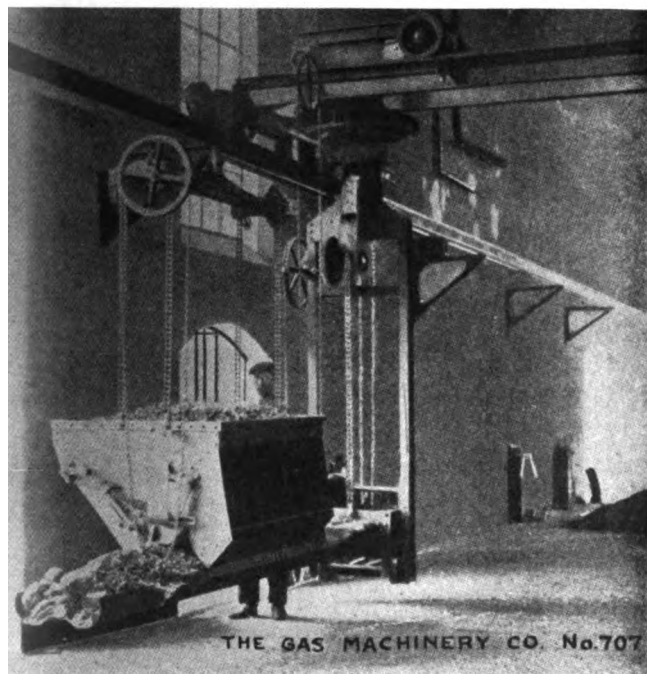


Fig. 2.—Hopper for filling coke charger.

ated coke pusher suspended from an overhead track. A manual coke pusher can also run on a track level with the charging floor, as shown in last year's report.

Fig. 1 illustrates a manual retort charger having the charging scoop made in halves. It runs on the same overhead track as the coke pusher, and may be filled from a hopper, as shown

in Fig. 2. This hopper is filled in the coal shed and run into the retort house on an overhead track. The manual charger may also be filled from an overhead coal storage hopper.

In addition to firing benches with gas made in producers

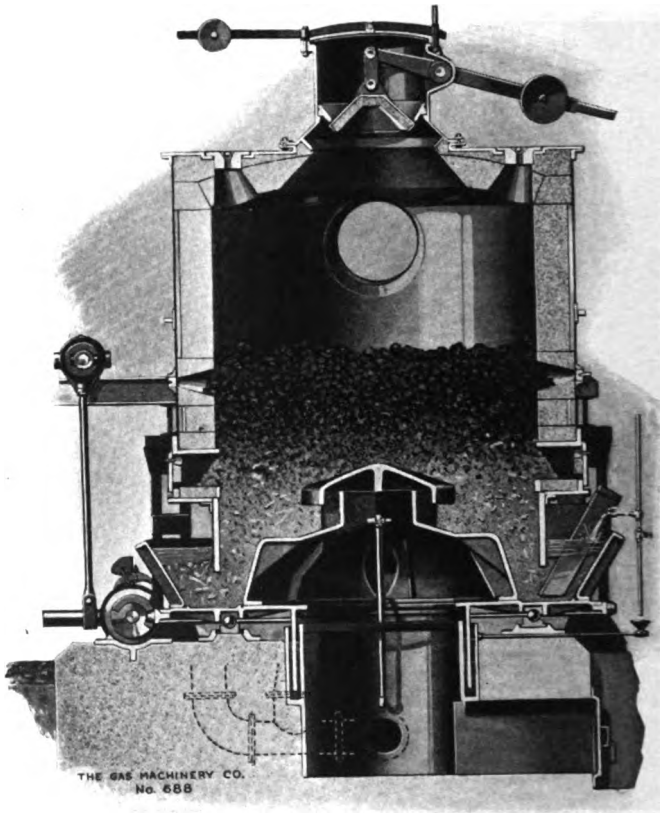


Fig. 3.—Gas producer with rotary grate.

provided with horizontal step and shaking grates, a gas producer with rotary grate suitable for burning bituminous coal, lignite, coke and other fuels, is shown in Fig. 3. The efficiency of this producer is high, as no heat is carried away by

ing water, and the fuel is completely gasified with the and forth motion of the rotating grate, and the ashes automatically discharged. As the air and steam enter the bed in a horizontal plane, this producer can operate with minimum depth of fuel.

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#### REPORT OF THE IMPROVED EQUIPMENT COMPANY.

*By E. Y. Sayer.*

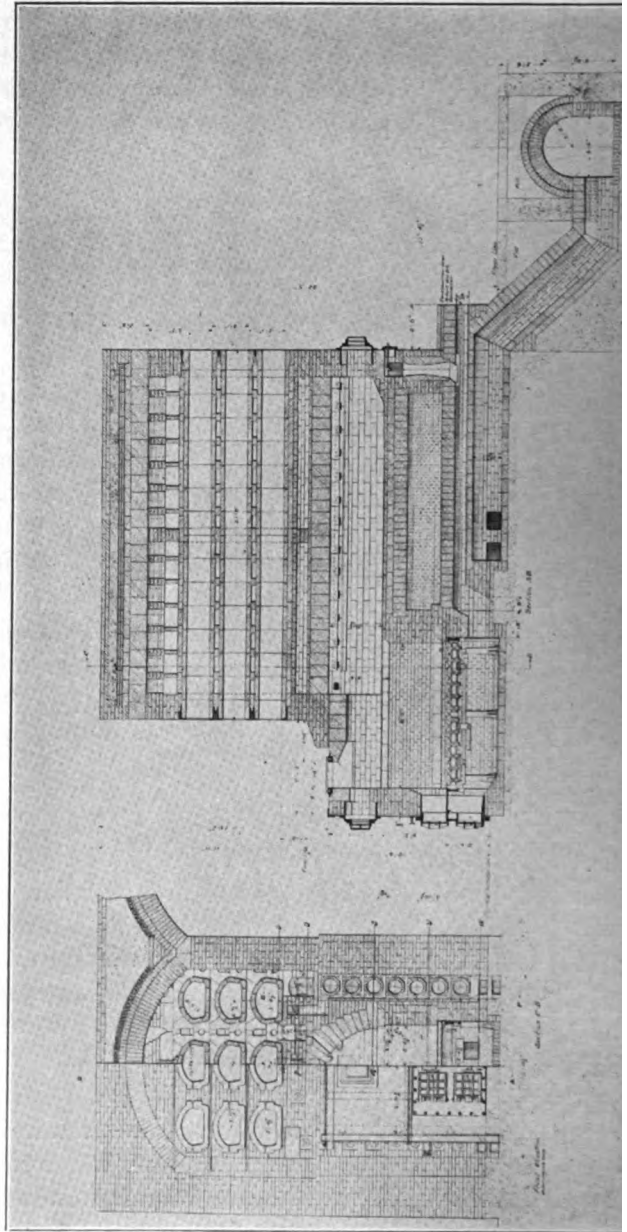
The large number of installations of the Doherty bench economizer, known as the CO<sub>2</sub> return system, made in the last few years has probably been due to the fact that it has entirely eliminated localized heating, more than to any other advantage, giving an even temperature throughout the settings and thereby prolonging the life of the retorts. The saving in the bench fuel and eliminating clinkers in the producer has been appreciated for some years.

The results derived from the use of silica material in sectional retorts and settings since the report of last year, have roughly demonstrated all the merits claimed for this material over the use of fire clay and the so-called one piece silica retorts.

#### *Philadelphia, Pa.*

The United Gas Improvement Company equipped eight of their old stop-end benches of 9's with the economizer at their Point Breeze Works, and are equipping 3 more at the same time, and at their Richmond Works, they are equipping 10 of their old stop-end benches of 9's with this process. Also, their installations of 7 vertical benches for Hartford, Conn., and Fall River, Mass., were equipped with this process.

In 1913, this company was awarded a contract for the installation of 5 arches and fillings of 21 ft. 0 in. through which for The United Gas Improvement Company at their



Point Breeze Works. In May, 1914, they awarded this company another contract calling for the installation of 7 arches

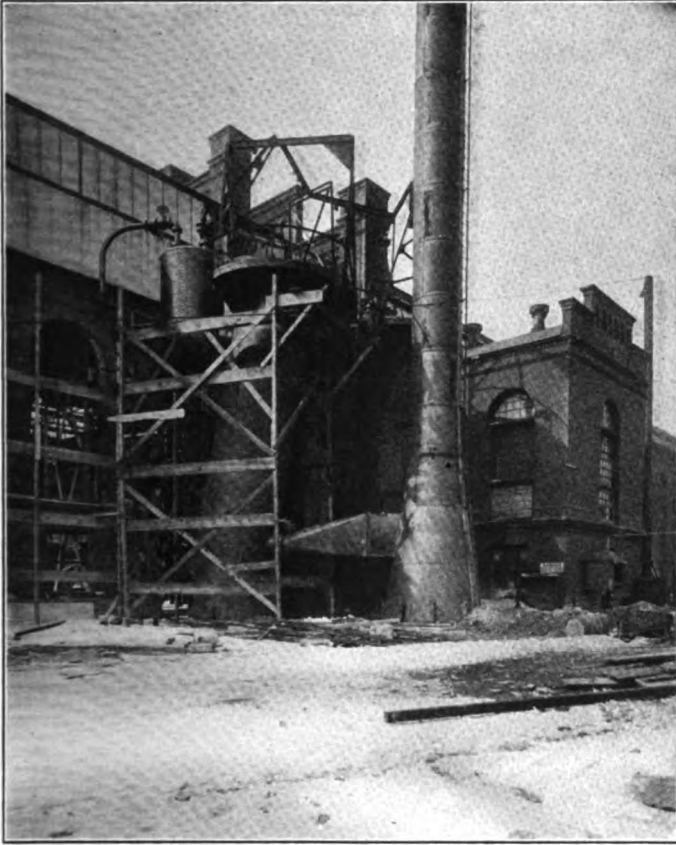


Fig. 5.—Waste heat boilers.

and fillings of the same design as the 5 previously installed. This design is shown in Fig. 4.

These benches are all equipped with sectional silica retorts and settings, and the special point of interest is the manner of applying the economizer to these fillings, the  $\text{CO}_2$  being



returned by means of fans from the outlet side of the waste heat boilers, shown in Fig. 5, through Venturi meters and under the producers. The secondary air for these benches is

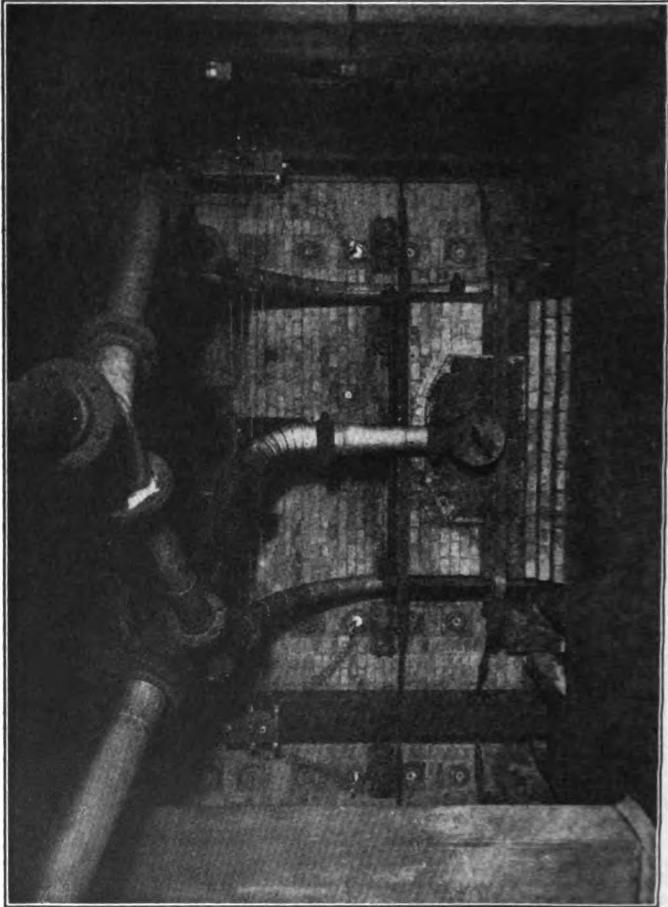


Fig. 6. — Venturi meters measuring  $\text{CO}_2$  and secondary air supply.

also introduced by means of forced draft through Venturi meters, as shown in Fig. 6. The producers are equipped with a special form of hand shaking grate. The front and back

ling of the stack of 7 benches consists of H. columns, and used for the support of the coal bunkers and the roof.

*Madison, Wis.*

The main points of interest connected with the installation of the new coal gas plant of the Madison Gas & Electric Company, consist in the unique telpher system installed by the gas company for the handling of the coal and coke, and the installation of 4 benches of 20 ft. 0 in. through 8's of silica material, the producers being of the partially extended type equipped with mechanical shaking grates.

*Salem, Mass.*

The Salem Gas Light Company awarded this company the tract for 3 arches and fillings of 20 ft. 0 in. through 9's, as their old retort house was in excellent condition, with exception that it was not of sufficient size to accommodate the new installation, they decided to raise the roof and make necessary extensions to accommodate the new equipment.

The coal is transported from the coal storage to the retort house by means of a belt conveyor into a bucket elevator, which dumps it into a drag conveyor feeding the overhead system.

The retorts are charged and discharged by means of a Brett-Hayward combined charging and discharging machine in the same frame, and the coke is transported by means of a DeBrouwer conveyor to a shaking screen, where it is sized to meet local conditions, and stored.

The producers are full extended producers, with double doors, so that the entire width of the producer is exposed during the cleaning period, which is once in 24 hours. The  $\text{CO}_2$  returned under the grates by means of one steam power injector located in the opposite end of each bench from the producer.

*Lynn, Mass.*

The first installation of large benches of inclines with sectional silica retorts and settings, was at the plant of the Lynn

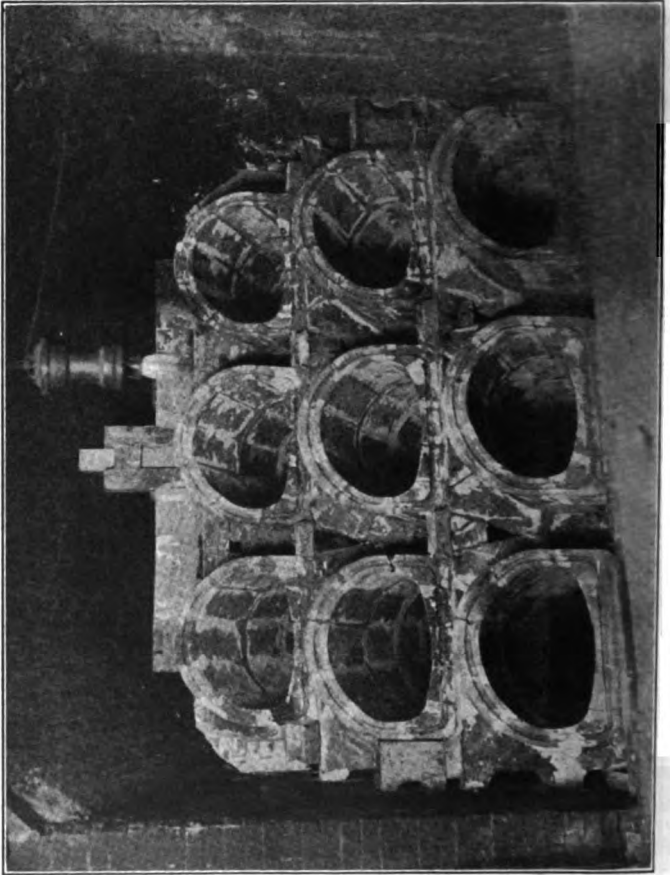


Fig. 7.—Upper end of special design sectional silica inclines.

Gas and Electric Company, the design of which was developed by this company in co-operation with the Lynn Company to meet the main objection to the inclined type of filling; that is,

the settling of the retorts soon after the bench had been placed in operation.

The first installation consisted of 2 fillings of 9's 18 ft. 0 in.

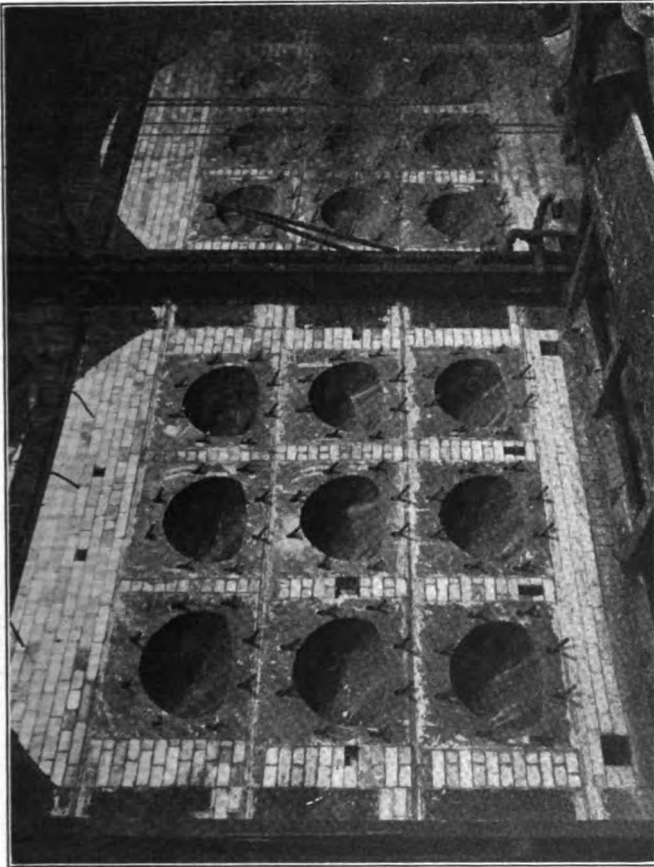


Fig. 8.— Mouthpiece lower end of special design sectional silica inclines.

retorts, and recently the Lynn Company awarded this company the contract for a duplicate installation of these fillings, which are shown in Figs. 7 and 8.

These fillings have the full extended producer equipped

with the economizer. One of the radical departures from past and present practice in the building of these inclines, and

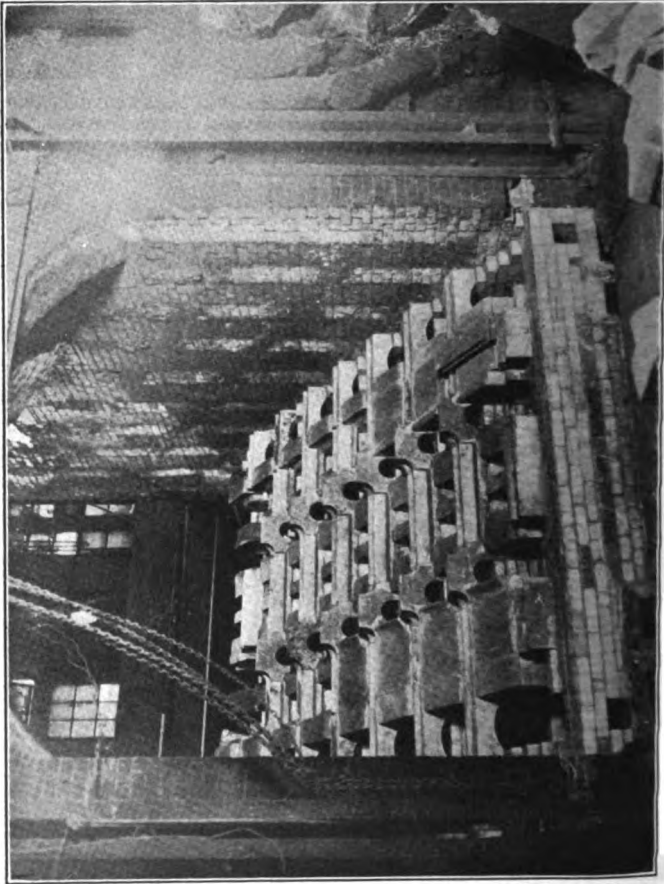


Fig. 9. — Commencing work of installing sectional silica inclines, showing horizontal supports.

which has thoroughly proved the merits claimed for it, was the adoption of a special design of sectional silica retorts, for which patents have been applied. Fig. 9 will bring out the details of this design, showing the manner of supporting the

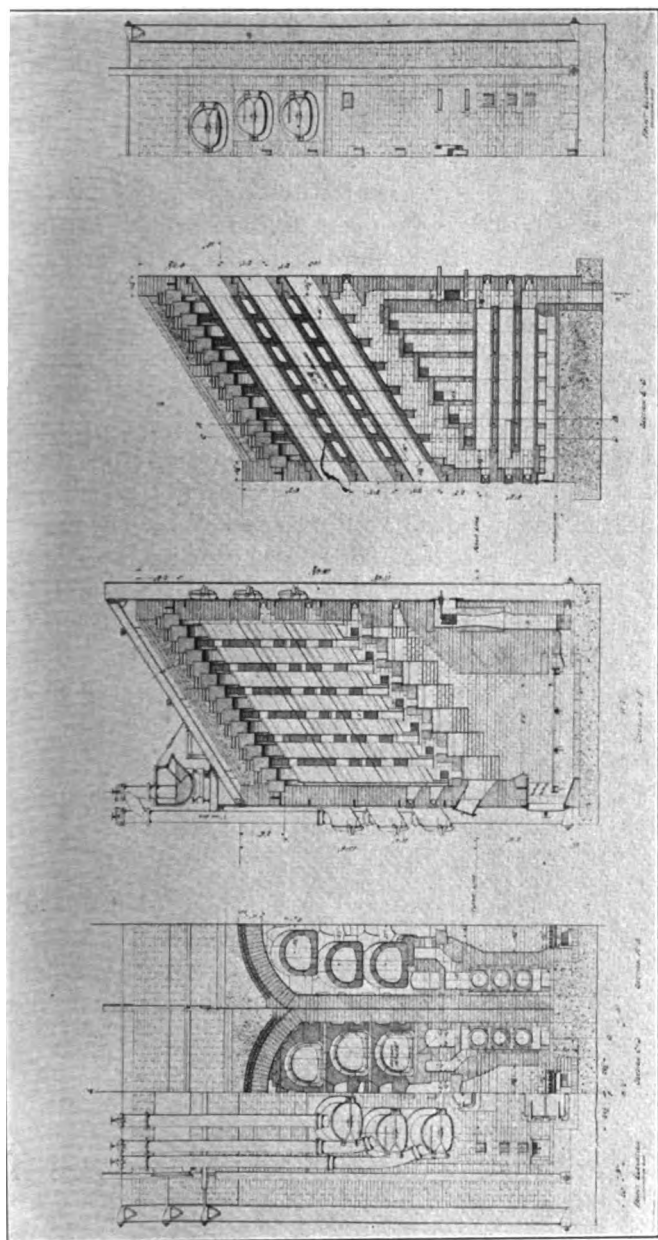


Fig. 10. — Small bench of incline sizers.

sectional silica retorts on the horizontal rests, instead of placing them as customary on an angle of  $32^{\circ}$  to  $33^{\circ}$ . This entirely eliminates the end thrust which has been a bad feature of incline installations.

No dampers have been used for the regulation of the amount of producer gas entering the combustion chamber, as this has been found unnecessary with the use of the  $\text{CO}_2$  return system.

To meet the condition obtaining in a small plant, we build small inclined benches of sizes, as shown in Fig. 10. These benches have a capacity of approximately 100,000 ft. of gas per bench per day, and will produce gas at a labor cost very little, if any, in excess of the machine operated house.

The gas man who has old type stop-end, hand charged benches of 6's, and whose local conditions will permit him to remodel these stop-ends to short throughs charged by hand and discharged by means of a hand operated machine, may increase his carbonizing capacity on his present foundations, and, at the same time, reduce his labor costs per thousand feet of gas made at a very small outlay. This type of installation has been made in a great many plants, and is giving excellent satisfaction in every respect.

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#### REPORT OF THE PARKER-RUSSELL MINING AND MANUFACTURING COMPANY.

*By D. R. Russell.*

In my last report, I referred to a number of plants which were then under construction but not completed. Since that time, the several installations referred to have been finished and put in operation, and in each case most excellent results have been obtained and a very large return in greater economy of operation and larger outputs.

It is difficult to secure data as to operation of plants, as it is the policy of many companies not to give out figures. I am indebted to Mr. R. C. Congdon, of Atlanta, Ga., for certain information as set forth in the following letter:

"This plant is equipped with the Congdon patent scrubber

standpipe system, and retorts 16 in. x 26½ in. x 21 ft. 7 in. long.

"When operating 10 benches of 9's, the labor required is as follows:

	Men per shift	Cost per M.
Bench fires .....	1.53	\$0.0032
The Fiddes-Aldridge charging and drawing machine .....	1	0.0043
Mouthpiece lids.....	3	0.0097
No labor on top		

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Total retort house labor per M		\$0.0172
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"When operating 6 benches of 9's, the labor required is as follows:

	Men per shift	Cost Per M.
Bench fires .....	1	\$0.0047
The Fiddes-Aldridge charging and drawing machine .....	1	0.0062
Mouthpiece lids.....	3.00	0.0107

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Total retort house labor per M		\$0.0216
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"We work 12 hour shifts and 7½ hour charges.

"The yield per pound of coal for the first 7 months of 1914 is 4.85 cu. ft. The average weight of charge is 1,364 pounds. We use Black Diamond R/M coal and Westbourne washed nut and pea coal, the latter amounting to about three-fourths of the coal used.

"The coal is brought into our retort house by a scraper conveyor. The coke is also handled with a scraper conveyor, which is arranged so that it can be operated in either direction. The coke going one way, drops into the coke bin, and in the other direction into the water jacketed coke buggies, which are mounted on rails leading to the various water gas generators. A small part of one man's time is required to look after the coke and coal handling.

"The coals we are using are of a cheap grade and probably would not compare favorably with Eastern gas coals.



"The average candle-power of the gas for the first 7 months of 1914 was 16.07. Candle-feet you will observe are, therefore, high. The gas was tested every hour throughout the period, using flat flame burner and the standard pentane lamp."

Another company for whom we constructed a plant last year, have benches of 8's with retorts 16 in. x 26½ in. x 20 ft. 0 in. long. Also, a Fiddes-Aldridge simultaneous discharging-charger machine and McDonald-Mann coke quenching bins. They have a track hopper, apron conveyor to coal crusher, belt conveyor to retort house, and longitudinal conveyor over continuous bins. The coke is drawn from the McDonald-Mann bins into cars elevated on platform elevator and pushed out over trestle to coke pile or to chutes for loading cars.

The total cost of the labor for operating either 7 or 9 benches from the track hopper to the coke pile is \$39.10 per day. The maximum wage is \$2.75 and the minimum wage is \$2.00 per day. They operate two shifts. The coke is handled only during the day shift. Coal used is Kentucky; weight of charge, 1,150 pounds; duration of charge, 8 hours; yield, about 5.10 per pound.

They are using Illinois steam coal with which to heat the benches. This coal is brought in through the same apparatus as the coal for the benches, but is diverted into a hopper placed in the retort house, from which it is drawn into cars and taken to furnaces.

They report that they have had no trouble whatever with the Fiddes-Aldridge machine, and the cost of repairs is practically nil. The plant has been operating for about a year.

During the past year, we have developed a special method of introducing steam under the grates of bench furnaces. This method has been installed at a number of different points, and has proven to the satisfaction of the different companies that clinker can be totally avoided. This apparatus is very simple and inexpensive, both as to initial cost, repairs and amount of

m used, and can be attached by any company. The operation requires no attention after once installed and regulated. At Taunton, Mass., we completed in July, 1914, the remodeling of a hand operated retort house into a modern up-to-date machine installation. The old plant consisted of stop-end benches of 6's, which were replaced by 6 through benches of 8's with retorts 16 in. x 26 in. x 20 ft. 0 in. g, constructed of sectional silica pieces with fire clay heads ported with specially designed silica tiles. The benches e full depth recuperation and furnaces of large dimensions, plied with superheated steam under the grates, and ipped with the scrubber standpipe.

A chimney, placed outside of the house at one end, and flues foundations, are so arranged to permit the installation r on of a waste heat boiler with by-pass connections.

The coal handling apparatus consists of a receiving hopper he coal shed, apron conveyor, crusher and a bucket elevator, latter delivering the coal into the overhead coal bunker of 0 tons capacity, from which the charging machine draws its ply.

The coke handling apparatus is constructed as follows: A re conveyor, extending the full length of the house in front the benches, receives the coke from the retorts and dis- rges it into a steel night coke bin on the outside of the ort house. This coke bin is arranged to deliver into wagons ich pass under it, or into buggies which can be elevated on platform elevator located inside of the retort house, and m there taken to storage in yard on overhead trestle.

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REPORT OF THE RITER-CONLEY MANUFACTURING COMPANY.

*By H. A. Carpenter.*

All of the retort houses in course of construction at the esent time by this company are provided with benches of retorts each, that is, 2 rows, 8 high. Last year's report of s committee gave an accurate idea of this setting of retorts. During the past year, a number of additions and improve-

ments have been developed in connection with this system of horizontal retorts. The retorts are charged and discharged by means of two machines working in conjunction, the one machine conveying the coal to the retorts, the second machine on the opposite side acting as a producer charger, as well as a transporting means to enable the operator to conveniently open and close the lids on the producer side for the discharge. The charging and discharging operation requires but two men, namely, an operator for each of these machines. Heretofore, in the operation of charging and discharging machinery for gas retorts, considerable time has been lost and inconvenience experienced in passing signals back and forth between opposite ends of the retorts, necessary on account of opening and closing lids and filling producers during the charging operation. A system has been developed whereby the lid of each retort on the producer side is locked and cannot be released until the lid on the charging side has been opened, and the operator on the machine conveying the coal to the retort cannot perform the charging operation until the lid on the opposite side has been opened; the result of this arrangement being that the operator of each of the two machines proceeds with his work without regard to the opposite end of the retort; that is, he opens his lid, places his machine in the required position and throws his operating switch, but the charging operation does not take place unless the operator at the opposite end has reached this point first, that is, has previously thrown his operating switch. It is claimed that this arrangement reduces the total time of the charging operation, as well as the time each retort is open to the atmosphere, prevents the opening of more than one retort at a time and decreases labor.

The charging machine is provided with an automatic weighing mechanism whereby a predetermined weight of coal is delivered to each retort. This mechanism is not under control of the machine operator.

The amount of coal delivered to the charging machine from

the storage bins is automatically weighed and recorded. To receive coal, the operator of the charging machine, without leaving his operating platform on the machine and without other manual assistance, runs the charging machine underneath the coal bin, placing it in a central position with the scales. He then moves forward an electric controller on the charging machine, which causes the hopper of the machine to be filled with coal, the amount weighed and printed on a recording cart, together with the date and exact time of the operation. After this work has been performed, the electric controller returns automatically to its initial position and the machine operator can then proceed with his work of charging the retorts, with no greater lapse of time in taking coal than is consumed in charging an individual retort.

The producer charger is provided with an automatic recording weighing mechanism, which records on a 24 hour chart the exact weight and time that material is placed in the producers.

All of these automatic weighing devices are under lock and key, with no part of them visible and their nature is not necessarily known to the operators of the charging machines, the intention being that the manager of the plant will, once in 24 hours, remove the record sheets and place the sheets for the succeeding 24 hours. Great accuracy is claimed for these weight records and much advantage in the manager of each plant having before him each day a printed record of the weight and time of each operation of all coal carbonized and fuel used in the producers, as well as the total weight of these items for the 24 hours.

A new type of centrifugal gas exhauster has been provided by this company during the past year. The exhauster is either turbine or motor driven, and in each case the entire exterior is covered by a gas-tight casing. All stuffing boxes, water seal bearings, etc., heretofore used have been eliminated. (See Figs. 11 and 12.)

It is the intention of this company to provide these ex-

hausters with an extremely sensitive regulating mechanism of a considerable range of sizes and pressures. At the present time, a 20 in. inlet pipe diameter steam driven machine of 12 in. differential pressure is ready for delivery.



Fig. 11.—Turbine driven exhaustor—Exterior view.

The system of patented vertical take-off pipes (Fig. 13) has been in use for 2 years, and during that time has thoroughly proven the elimination of the greater part of the arduous labor common in connection with the operation of take-off pipes for gas retorts. In the first plant constructed,

a circulating system was maintained and the gas was cooled in the vertical pipes by the introduction of water at the top of the pipe. It appears desirable, however, to maintain as

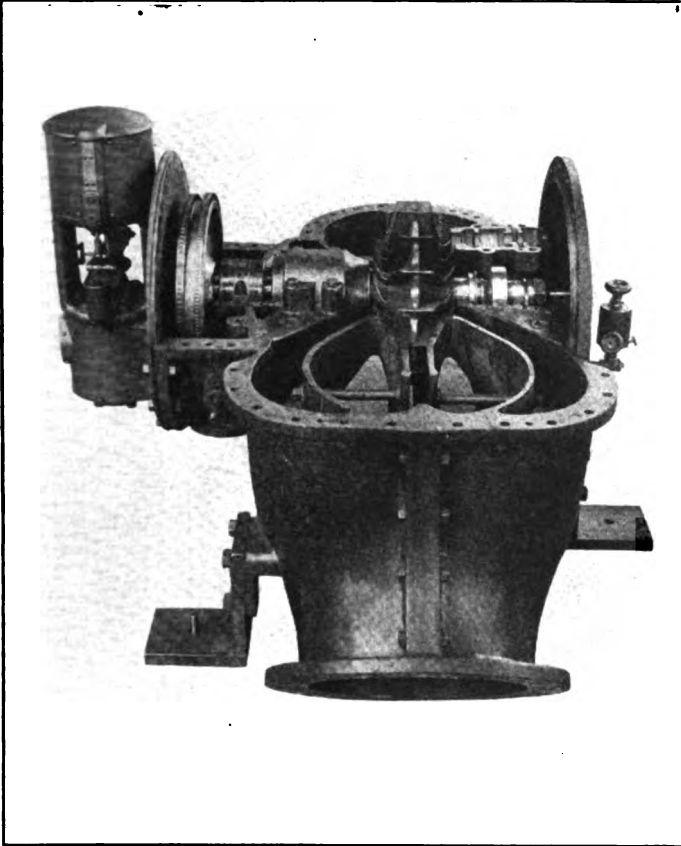


Fig. 12.—Turbine driven exhauster—Interior view.

high a temperature as practical in these vertical pipes, in order to secure a fixing action for the large volume of low temperature gas emerging from the freshly charged retort, and in all new plants under construction, water will not be intro-

duced into the pipes. It has been argued by some that if a sufficient amount of circulating liquid were passed through a pipe of this nature, tendencies toward stoppages or formations

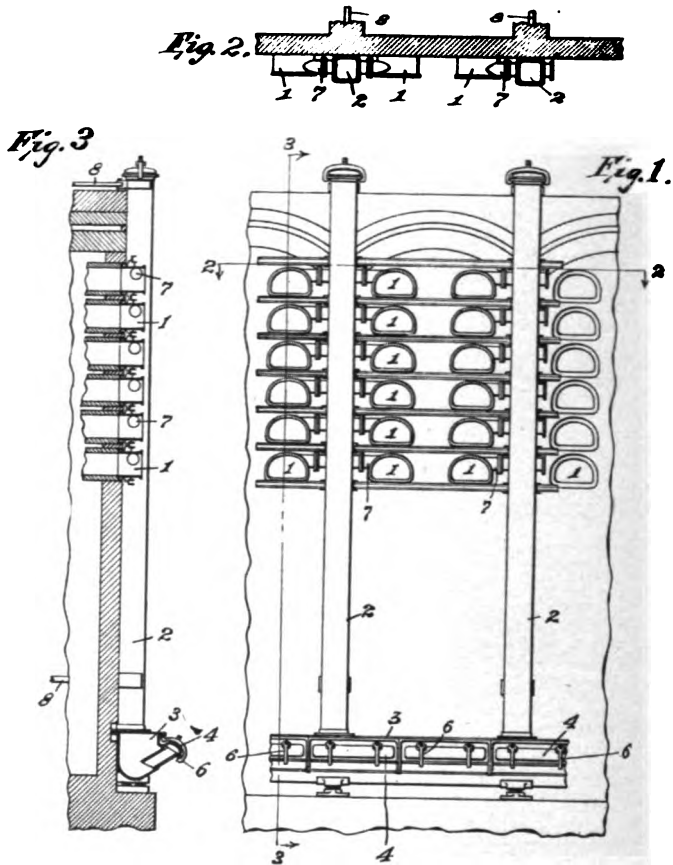


Fig. 13.—Vertical take-off pipes.

on the sides of the pipe would at all times be eliminated. Careful consideration and observation has resulted in the conclusion that if an economical carbonizing temperature is main-

tained within the retorts, these pipes must have a certain amount of attention to prevent formation within, even though larger quantities of liquid are circulated; and the advantage gained by the thorough mixing of the gases from the various retorts, and travel through this pipe at a comparatively high temperature, is greater than that resulting from any tendency toward elimination of formation inside the pipe by the process of cooling the gas by a circulating liquid during its travel therein. In order to reduce the necessary attention to these pipes to a systematic operation, we have provided in all plants now under construction a cleaning apparatus especially designed for this purpose. The top of each vertical pipe is closed by the gate valve, the open area of which is the inside area of the pipe. A cleaning compartment, with a cleaning tool therein, mounted on an electric hoist directly over the pipes, is adapted to be connected to the top flange of the gate valve mentioned, by self-sealing clamps, after which the gate valve is opened and the cleaning tool lowered through the pipe, opportunity being provided at the bottom of the pipe for discharging any formations thus removed. By this principle of cleaning the vertical pipes, they are not opened to the atmosphere and the man attending the cleaning operation is not exposed to escaping gases or undue heat.

During the past few years we have considered carefully the insulation of the exterior of the retort benches, in order to reduce losses of heat through radiation. After building a number of different forms of structures for this purpose, it has been concluded that the most satisfactory way to insulate a stack of retort benches is to surround it completely with a metal casing, with a highly efficient insulating material interposed between all parts of the metal casing and the refractory structure of retort benches within. Three large contracts of this design are in the course of construction at the present time and a great reduction in radiation losses is expected to result. The many other advantages of surrounding the structure with such a metal casing will suggest themselves.



THE DEVELOPMENT AND OPERATION OF THE CONGDON  
SCRUBBER STANDPIPE SYSTEM.

*By R. C. Congdon.*

Included in the report of the Trustees Gas Educational Fund for 1906, and published on pages 112 to 116 of Volume 1 of the PROCEEDINGS of the American Gas Institute, was the following question and its answer:

"Question 6. Give your theory of the causes of stoppages in the standpipes of coal gas retorts and the means you would employ to prevent them."

The theory as set forth by the trustees, I think is for the most part correct, but the cooling methods referred to have never proven practical, and consequently a great many men are still employed in this and other countries at the very arduous task of keeping standpipes open. I know of one plant where the pipes are cleaned every 6 hours. The retorts are of silica material and high heats are carried. The De-Brouwer charger is used and very heavy charges are laid. The work of keeping the pipes open represents the interests on \$84,000.00 at 6 per cent. Other plants use mechanical pipe cleaners, while others endeavor to avoid the trouble by carrying low heats with corresponding low yield and with accompanying loss of money.

Silica material is rapidly coming into general use, high heats are the rule and standpipe troubles follow. It seems impossible to get high yield and high candle-power without cracking up some of the hydrocarbons. The carbon thus liberated, together with tar formed on the inside of the standpipe, furnish the ingredients for standpipe stoppage.

As evidence of the standpipe troubles experienced in Atlanta, see Fig. 14. This picture shows a section of an 8 in. steel standpipe removed from our plant after it had been in service 6 days without cleaning, and had been allowed to stop up.

During the year 1912, our company remodeled its coal gas plant, a description of which was given in a paper read by me

ore the Southern Gas Association in 1913, and published in various gas journals. Briefly, the plant consists of 11 rough horizontal benches of 9's, having retorts 16 in. x  $\frac{1}{2}$  in. x 21 ft. 7 in. long. The gas from each retort was ried to the hydraulic main by a steel standpipe 8 in. in



Fig. 14.—Section of 8'' standpipe, after six days' use.

diameter. Modern coke and coal handling apparatus was installed, the latter including a Fiddes-Aldridge combination charging and discharging machine, which is capable of laying a charge of 70 pounds per lineal foot of retort.

The through benches installed, replaced 22 stop-end 9's, and the labor on and above the operating floor was reduced from 53 to 12 men per 24 hours. Four of the 12 men, or one-third of the labor, was required to keep the standpipe,

bridgepipes, and hydraulic mains clean. The standpipe problem was thus brought forcibly to my attention. My many experiments and study have resulted in a plant which has been operated for a year, and during which time the standpipes, bridgepipes, and seal boxes have remained perfectly clean, necessitating no labor whatever.

It was with a delightful sense of relief that I read Mr. Alfred E. Forstall's article in the September issue of the *Gas Institute News*, in which he concludes his remarks with the following: "The difference between good and poor management consists largely in the amount of attention paid to these small details of operation." By the scrubber standpipe system (so-called because a considerable part of the work of the usual hot scrubbers is accomplished in the standpipes), we have eliminated the details relative to standpipes, mains, etc., and are, therefore, spared the attention, and hence, the relief.

The attempt to prevent standpipe stoppages by trickling water through them is old. Heretofore, however, of necessity, the water had to be very limited. The difficulty of regulating the streams to prevent flooding the retort, even if the volume of water proved adequate, would still be a sufficient cause for failure of this method.

The water jacketed standpipe has also proved a failure, primarily because the cooling effect was not sufficient to cause an ample quantity of tar to condense and flow into the retort.

I conceived the idea of causing a moving film of liquid to continually pass over the inside surface of the standpipe,—a moving platform as it were. I reasoned that no stoppage could occur so long as this platform kept moving. Instead of attempting to condense the tar in the standpipe to cause a moving film, I intended to send a stream of tar over a dam at the upper end of the pipe. Evidently, the tar thus supplied to the ordinary standpipe would flood the retort. This difficulty suggested by-passing the retort and sealing the lower end of the pipe in an open trough,—open in the sense that it

is not required to be gas tight. The trough would contain only the circulating fluid.

Fig. 15 shows our first experimental apparatus. The stand-pipe shown was first connected to one retort, a separate tank or hydraulic main above was provided, and the pipe was carried through the operating floor to a seal in the basement. A "Y" connection was used to prevent disturbing the mouth-

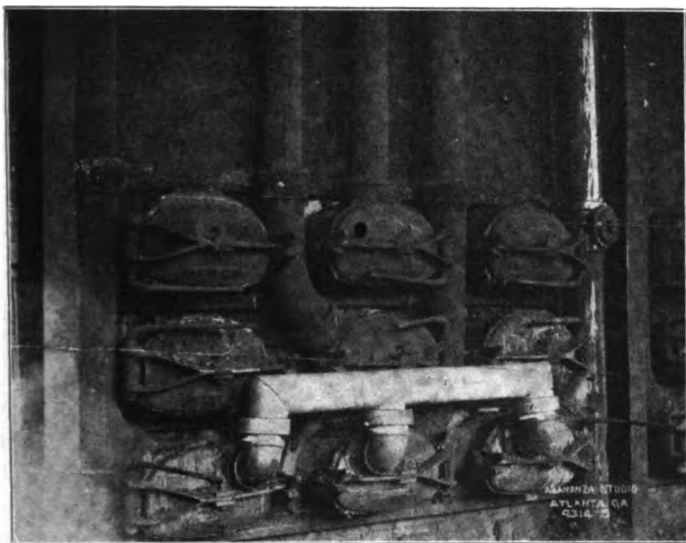


Fig. 15.—Experimental standpipe.

piece. A stream of water was sprayed at the top of the pipe, instead of tar as first contemplated, and a tee and plug were conveniently located in the pipe for observation purposes. A thermometer was placed at the bridgepipe and temperatures regularly taken.

Later, 3 retorts were connected as shown, and it was found that the 8 in. pipe would successfully carry the gas, and that no stoppage would occur.

After a month's test, the result of this experiment showed :

- 1st. If water was introduced in sufficient quantity, the standpipe, both above and below the floor, would remain perfectly clean.
- 2nd. No pitch or heavy tar would accumulate in the bridgepipe or hydraulic main.
- 3rd. If the temperature at the bridgepipe was carried as low as 120 deg., practically no tar would accumulate in the upper seal; if carried at 180 deg., two-thirds of the tar went below. The tar condensing on the side of the standpipe furnished the moving film above referred to, and the introduction of tar at the top of pipe was found to be unnecessary.
- 4th. As the troublesome lampblack and heavy tar are condensed and washed out of the gas, the dip pipe can be unsealed and no stoppages occur.
- 5th. The tar in the upper seal was very fluid and usually lower in carbon than tar in the lower seal.
- 6th. The lower seal would require very little attention, since the tar collected there was sufficiently fluid to run.
- 7th. As the standpipe remained perfectly clean, a valve could be successfully operated on the inside, and in consequence, the retorts in a vertical row could be connected to a single pipe.
- 8th. Retorts from adjoining benches could be connected to a single or to a divided pipe, or two pipes could be used, one pipe placed on either side of the buckstay.

The design as finally worked out for a bench of 8's, is shown in Figs. 16 and 17.

Standpipes rectangular in section, are arranged on either side of the buckstays, and are connected to the adjoining rows of retorts. The standpipes of each bench are sealed above in a wash box or seal tank, and below in a concrete trough extending the length of the house and enlarged into a tar well at one end. The gas from the various wash boxes is collected into an overhead foul main and is taken from the retort house

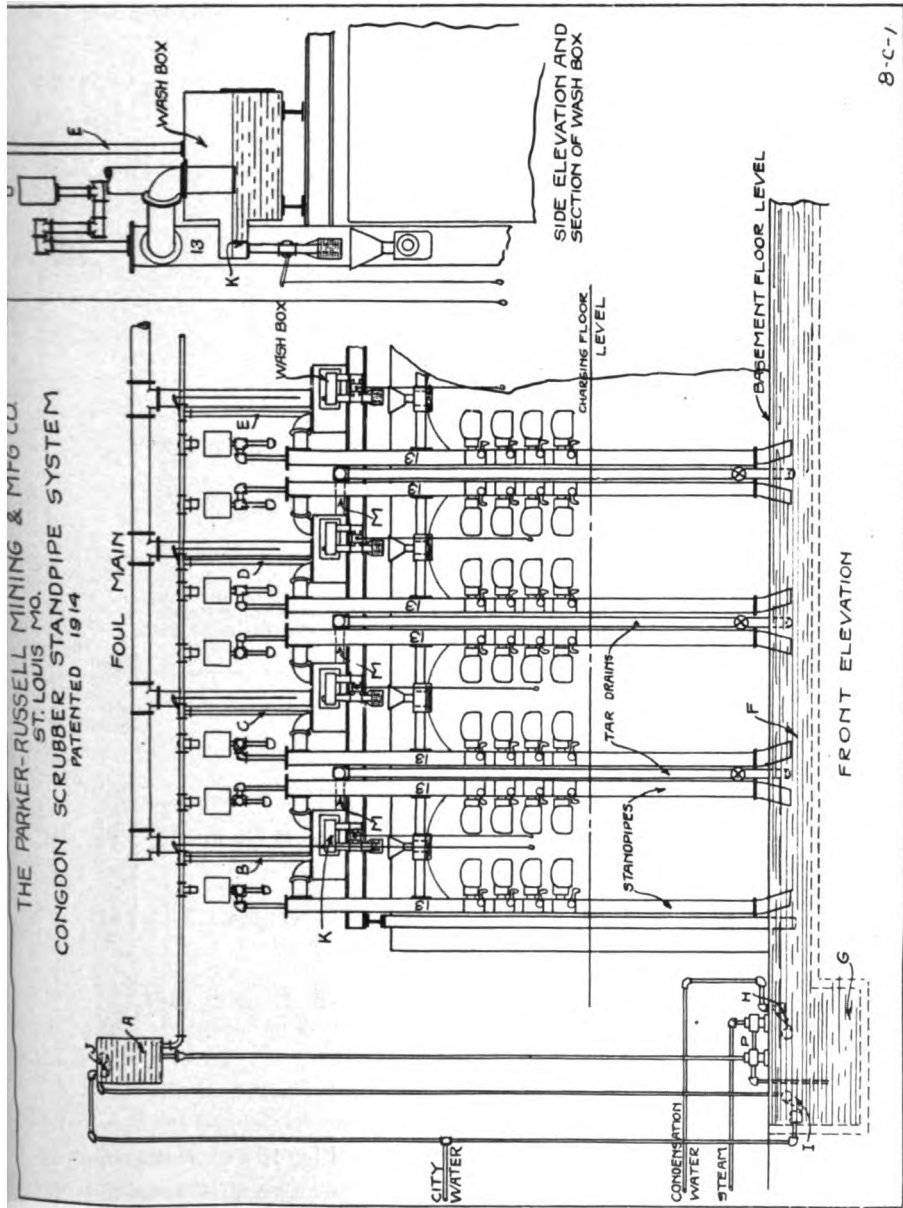
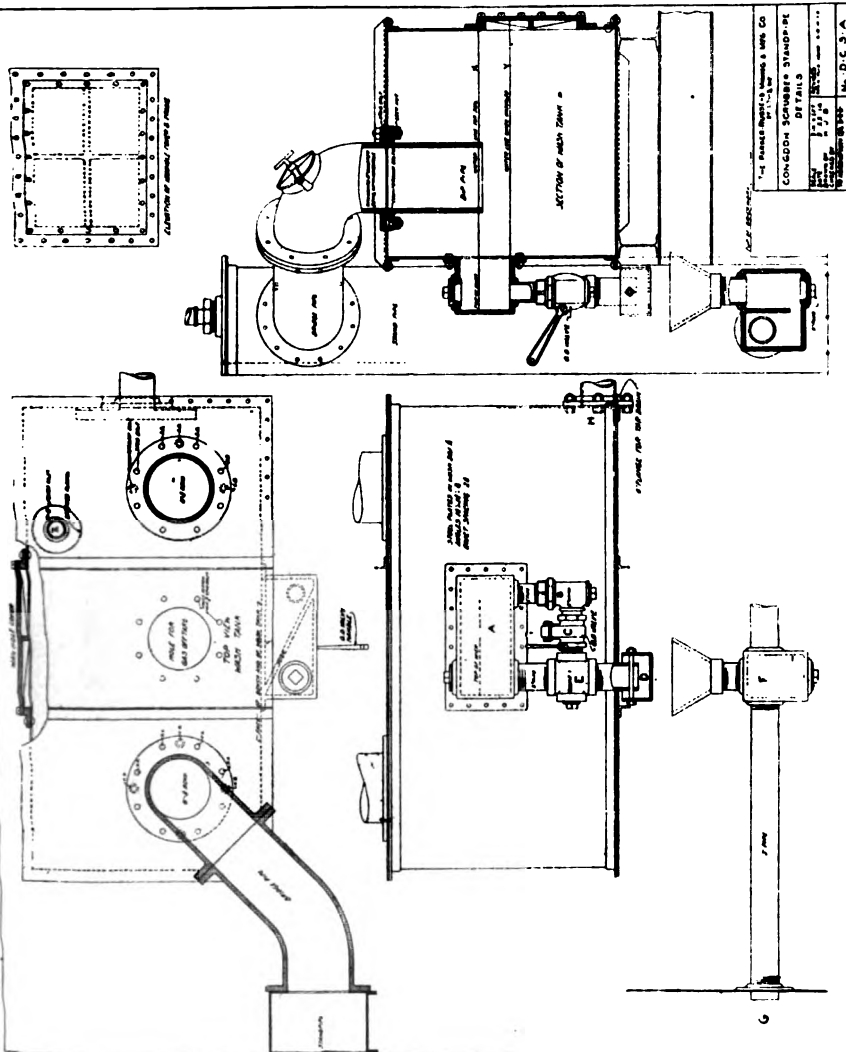


Fig. 16.—Scrubber standpipe for bench of 8's.



to overhead tank "A." This liquor then flows through the



**Fig. 18.—Seal tank or wash box for scrubber standpipe.**

various funnels shown, into and through the standpipes to the lower seal, where it is again picked up by the pump. "I" and "J" are float valves controlling city water. "K" is a float valve



on the condenser water supply line—either water supply can be used to replace tar pumped from the lower seal to storage.

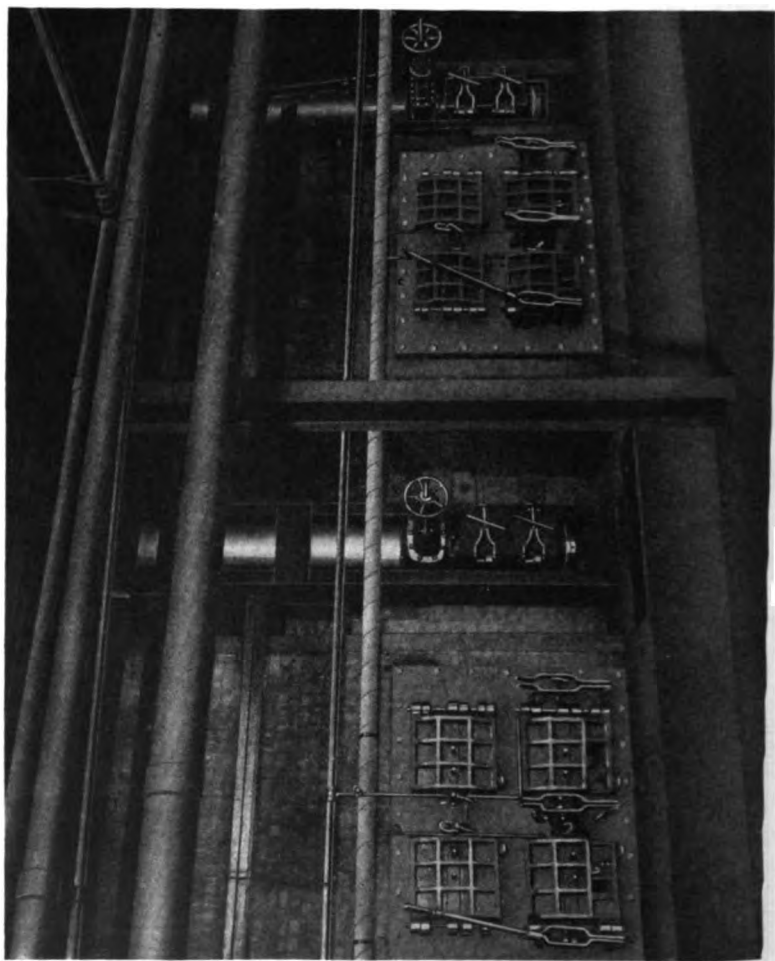


Fig. 19.—Lower end of scrubber standpipe.

Our experience has demonstrated that the bridgepipes will not stop up, hence the adoption of the standard steel pipe and elbow in lieu of the usual bridge casting. The dip is also made

of standard steel pipe. The overflow seal box "A" has a drain "B" controlled by quick opening valve "C"; waste "E" is sealed in pot "D." (See Fig. 18.) This seal pot serves a double purpose. If the exhauster should stop, the seal would blow and thus relieve all back pressure. This pot also enables the operator to know when the dip is sealed, for when the pot overflows, it is a sure indication that the liquor in the seal box "A" is overflowing the weir, the top of which is above the lower end of the dip pipe.

The overflow liquor passes through the safety seal "F" and into the standpipe "G," discharging into the lower trough. This safety seal "F" is provided to prevent the gas from blowing at the end of the standpipe deeply sealed in the lower trough, should by any chance the bridgepipe become clogged, and also to seal the connection between the funnel and the standpipe. You will note by Fig. 19 this safety seal is not provided in our installation. Our experience demonstrates that it is not really necessary, but it might be installed as a precautionary measure to meet very adverse conditions. Should a cloud of lampblack get by the spray in the upper end of the standpipe, the bridgepipe might stop up.

When ready to charge, the dip pipe is sealed to prevent drawing in air. As soon as the charge is made, the valve "C" is opened, and the level of the liquor inside the seal tank or wash box falls from "X" to "Y." When it is desired to again charge the retort, valve "C" is closed and water is admitted at "Z" until the seal pot "D" overflows. The sealing and unsealing operations are accomplished from the charging floor by means of extension valve stems. (See Figs. 20 and 17.)

The seal tank or wash box is provided with a manhole cover to allow access to the inside, should occasion require. The seal tanks in our plant have required no attention, and in consequence, the usual cleaning pockets have not been needed.

Tar is drained from the seal tank at "H," and flows to the lower trough, through a pipe which is sealed in the lower trough and is provided with a valve "E" (Fig. 17). Once a

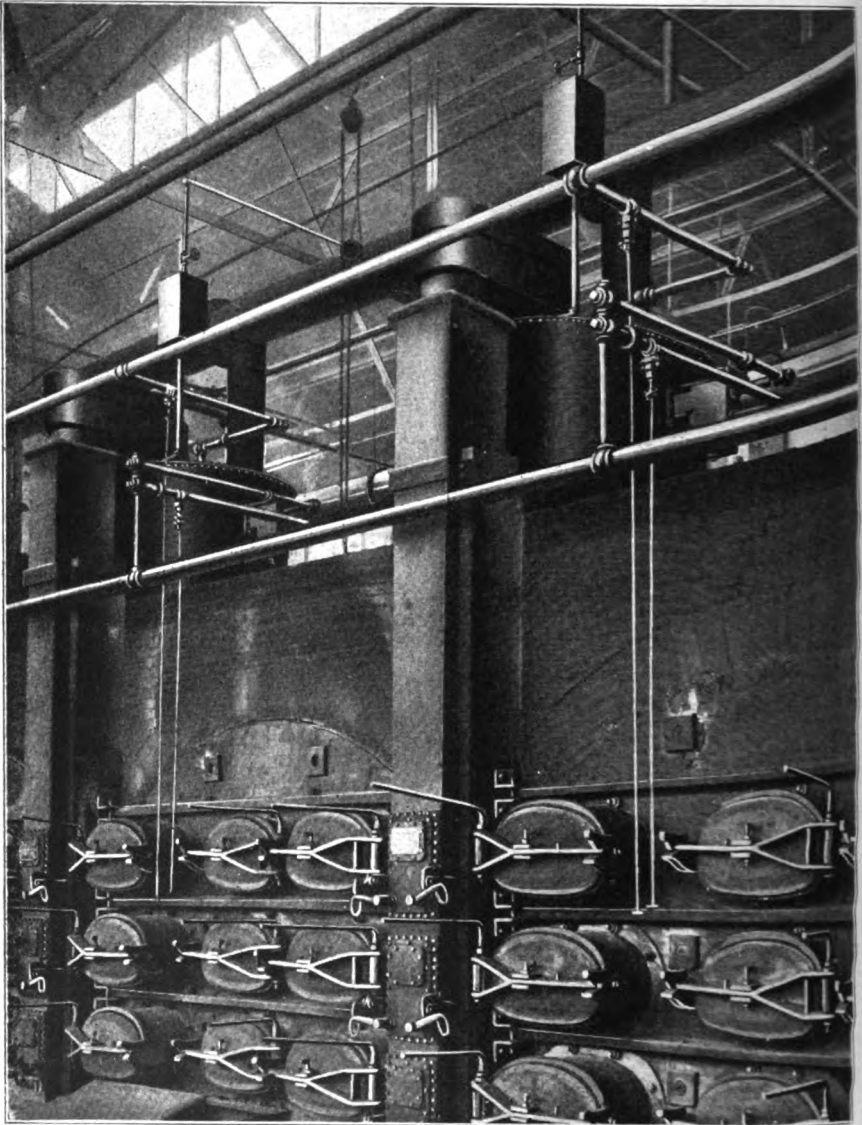


Fig. 20.—Upper end of scrubber standpipe.

day we draw off the tar by opening this valve. When liquor shows at test pipe "D" (Fig. 18), valve "E" is closed. The

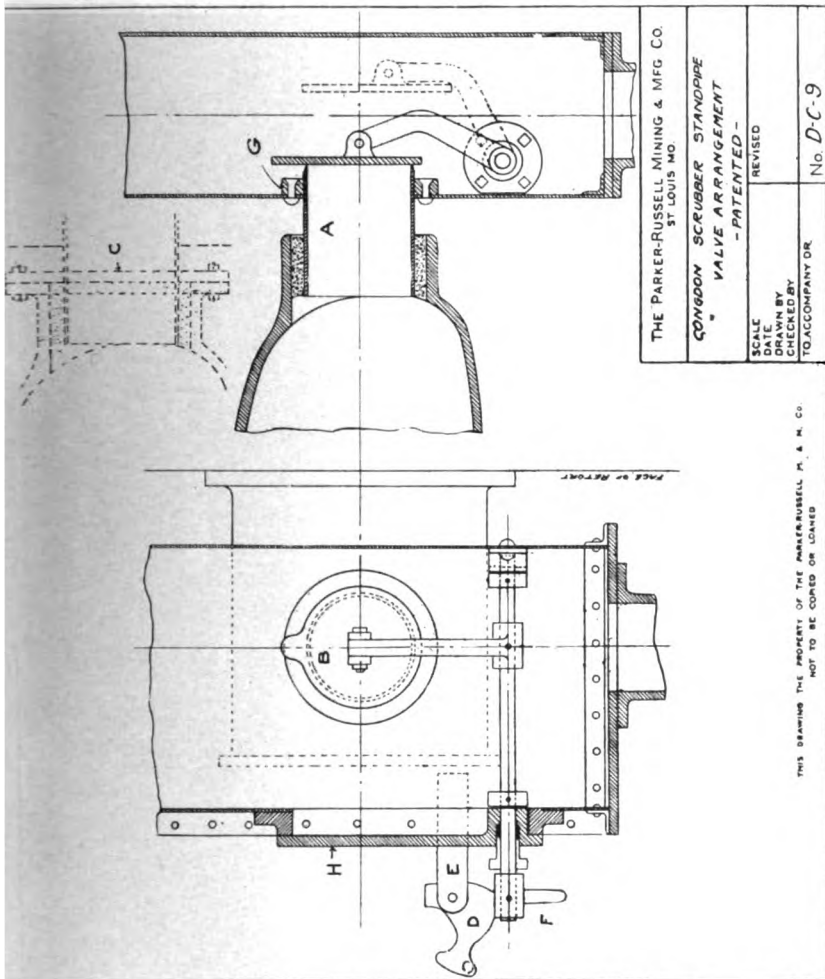


Fig. 21.— Valve arrangements for scrubber standpipe.

lower trough requires practically no attention, occasionally the pocket under the standpipe is cleaned, the firemen attending to this work.

Fig. 20 shows the construction as applied to benches of 9's,

the middle retorts being connected to a single pipe on the opposite side of the bench. Fig. 19 shows the drain pipe and

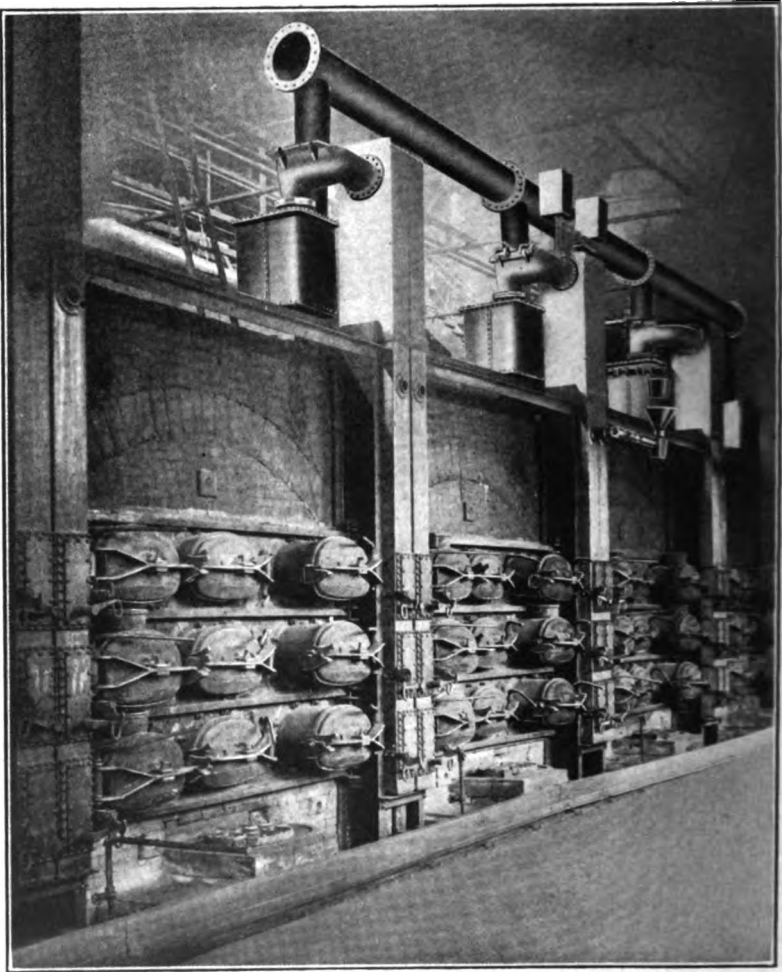


Fig. 22.—Double scrubber standpipe.

lower seal or trough. Fig. 22 shows a later construction, differing from the other in that the single standpipe has been

replaced by a double one. How many of you would say, in the absence of our experience, that valves located in the stand-pipe would give absolutely no trouble and would remain per-

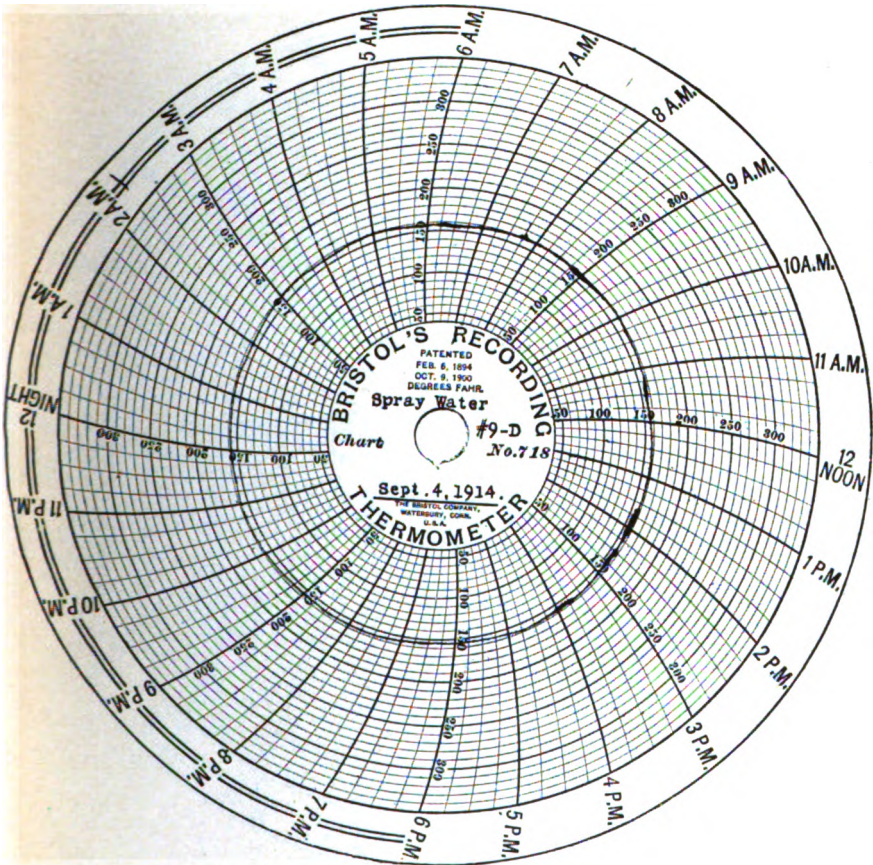


Fig. 23.—Record of liquor temperature at scrubber standpoint top.

fectly clean throughout an entire year. Many engineers have visited our plant and all have been greatly impressed with the condition of the valves and the inside surfaces of the stand-pipe which appears to have just been painted.

Not a valve has given any trouble whatever, each has served



the purpose for which it was adopted, namely the prevention of waste of gas from the standpipes during charging periods. Also, as no gas escapes to burn at the mouthpieces, the men

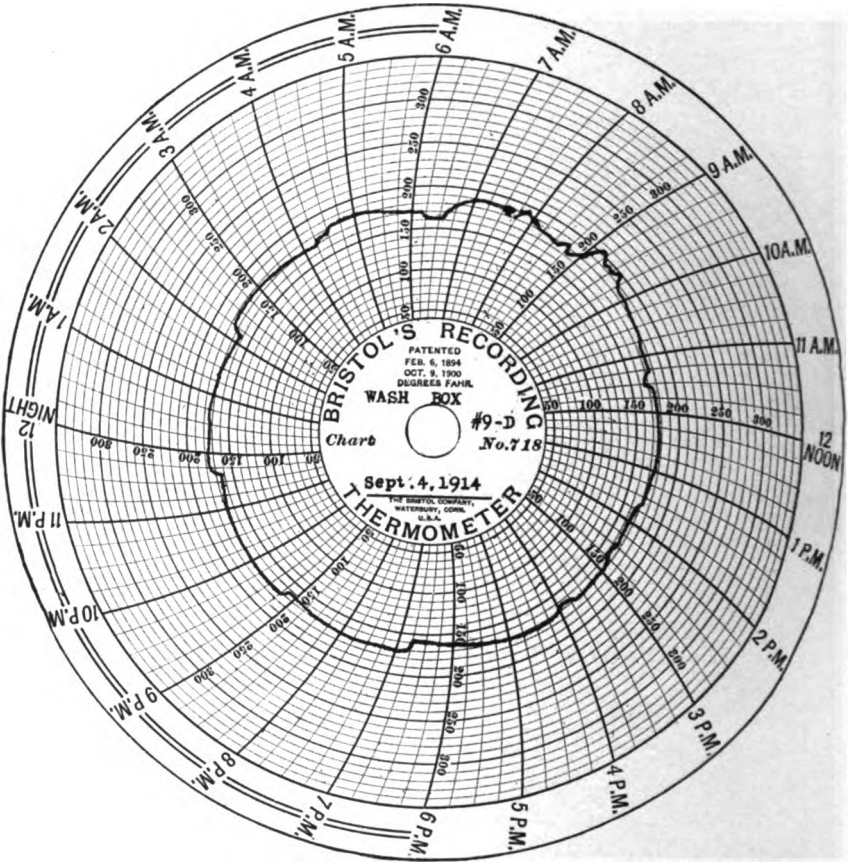


Fig. 24.—Record of gas temperature at wash box outlet.

are not subjected to the great heat which they would otherwise have to endure were the valves omitted, and because the valve is on the standpipe end of connecting pipe "A." (Fig. 12) they can see what they are doing when cleaning the retort

standpipe connections. The closed valve prevents the dry dust from falling into the standpipe, and gas from blowing out.

Fig. 21 shows the details of the valve construction. The

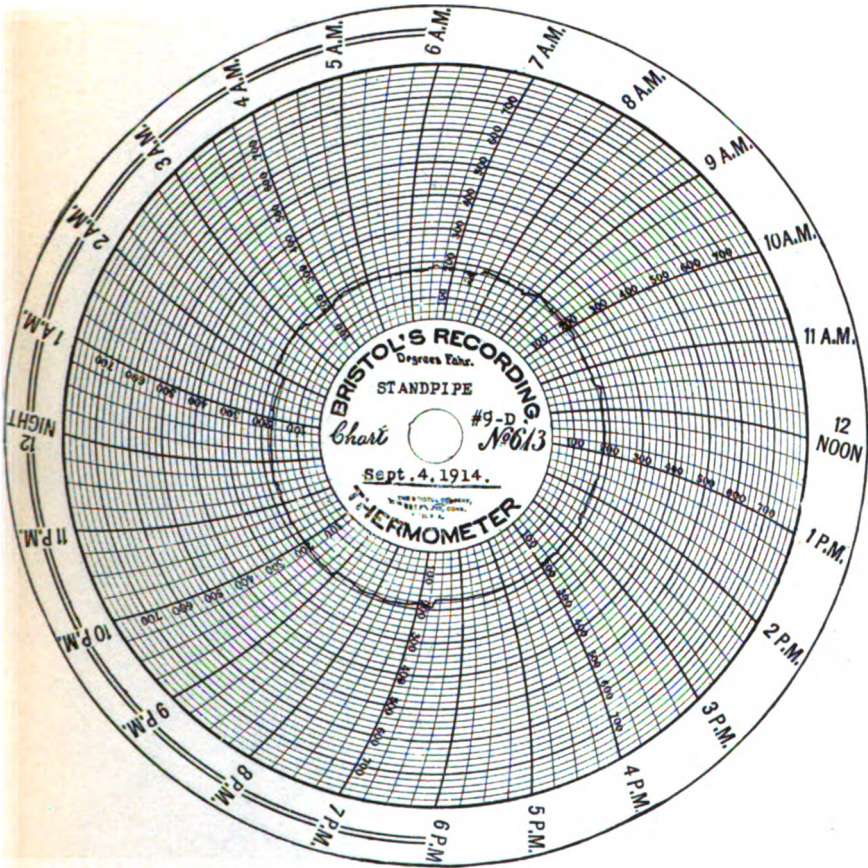


Fig. 25.—Record of temperature in scrubber standpipe just above lowest valve.

valves are supported on a removable plate "H" bolted to the face of the standpipe, and are seated on the edge of the steel connecting pipe "A," screwed into a flange "G," riveted to the inside of the pipe. There is a slip joint between the connecting pipe and the mouthpiece, although a stop may be pro-



vided for the joint packing by the use of a disc "C" shown bolted to the mouthpiece. We have not found the disc necessary. The eccentric latch holds the valve closed while a

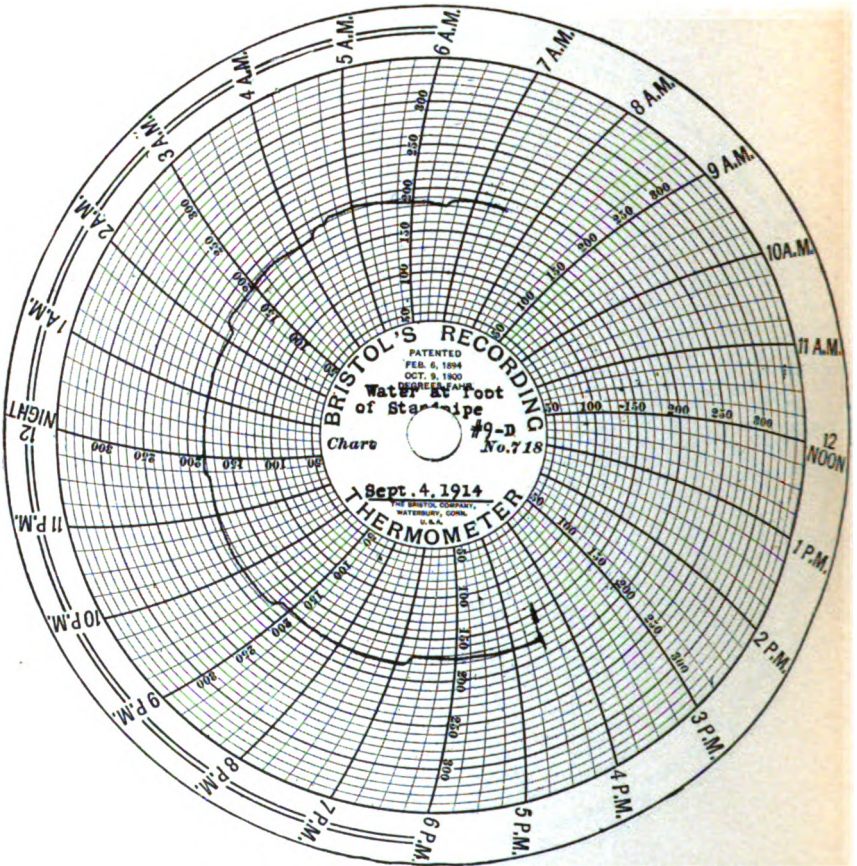


Fig. 26.—Record of liquor temperature immediately below scrubber standpipe.

charge is being made. The latch is easily released, and when it is thrown back, the valve opens and is stopped at the proper location when lever comes in contact with latch support.

Fig. 23 shows the temperature of the liquor as it goes into the funnel at the top of the standpipe. You will observe how

very constant this temperature is. Fig. 24 shows the temperature at the outlet of the wash box or seal tank. The chart shows how the temperature rises at the time of making each charge and indicates a low temperature in the seal tank.

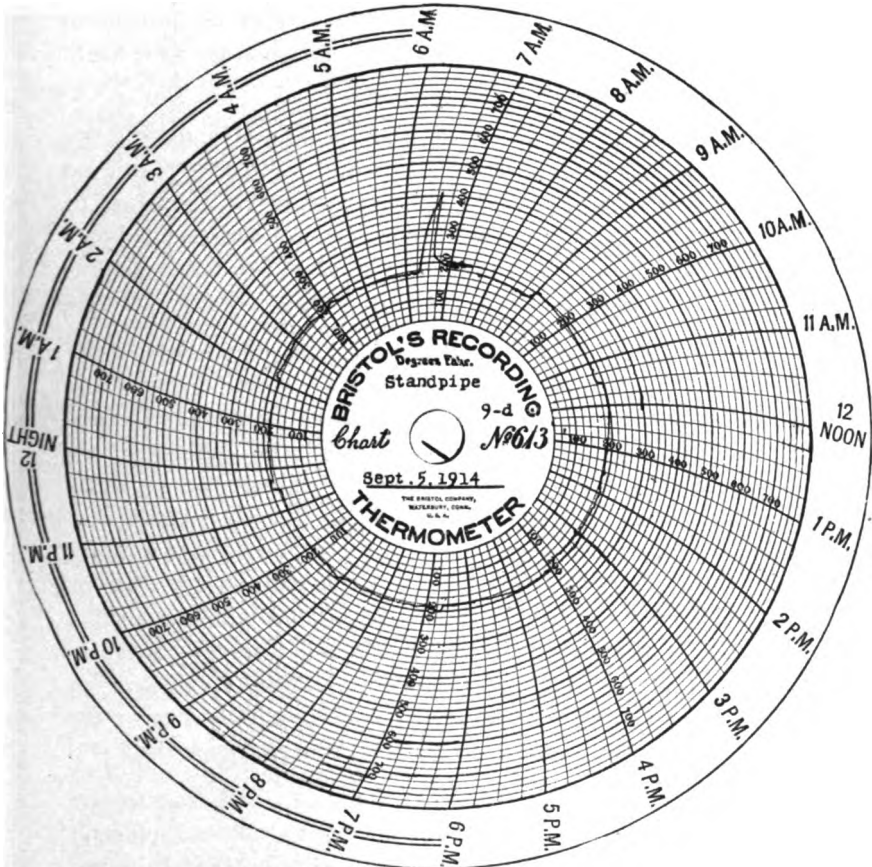


Fig. 27.—Temperature rise due to cessation of liquor circulation.

Fig. 25 was obtained by placing the thermometer inside the standpipe just above the lowest valve. This chart proves that the valves are not subjected to high heat, although located in the hottest part of the standpipe.

Fig. 26 shows the temperature of the liquor in the lowest seal or trough and immediately below the standpipe. The tar from the standpipe sinks to the bottom of the trough, and is always deeply covered with hot liquor which follows it to the tar well, and in consequence, there are never any tar lines to steam out during cold weather. Some sort of tar line must be provided to take the tar from the retort house to the well, and the lower trough serves this purpose.

Fig. 27 shows the effect of discontinuing circulating the liquor. A test made covering a period of 3 hours and no liquor circulating showed the temperature in the standpipe to be 700° F. The circulating system can be discontinued for several hours without causing any trouble; we have demonstrated this many times.

The cost of operating the pump we have not definitely determined. This expense, however, would not all be chargeable to the standpipe system, since a part of the work of the scrubbers is accomplished in the retort house. The indications are the expense will be small. Since operating the scrubber standpipe system, we have sent through each standpipe 2 gallons of liquor per retort per minute, although tests indicate this quantity to be much in excess of the actual need. As our plant is now arranged, the pump forces the liquor against a head of 54 ft., in transferring the liquor from the lower to the overhead tank. This head can be reduced by at least 15 ft. The theoretical horse-power now required is 2.7; the actual horse-power, based on 50 per cent. efficiency, is 5.4.

It gives me great pleasure to extend an invitation to any who may be interested in this apparatus to visit our plant at Atlanta, Georgia. Several companies have ordered this new equipment, and you will soon be able to see it in operation elsewhere, but I would enjoy the pleasure of welcoming you in Atlanta.

## OPERATING RESULTS.—Wet Basis.

Yield of gas per pound of coal, first 7 months of 1914..... 4.85  
 Yield of gas per pound of coal, first 7 months of 1913..... 4.80

Candle-power, first 7 months of 1914..... 16.07  
 Candle-power, first 7 months of 1913..... 15.20

Note: Pentane lamp and flat flame burner used.

Candle feet, first 7 months of 1914..... 77.93  
 Candle feet, first 7 months of 1913..... 72.96

Yield of tar per short ton of coal 1914..... 13 gals.  
 Tar estimated in 1913..... 13 gals.

Yield of ammonia, first 7 months of 1914, per short ton of  
 coal carb. .... 4.16 lbs.

Yield of ammonia, first 7 months of 1913, per short ton of  
 coal carb. .... 4.24 lbs.

Yield of ammonia, first 7 months of 1912, per short ton of  
 coal carb. .... 3.15 lbs.

Yield of ammonia, first 7 months of 1911, per short ton of  
 coal carb. .... 2.95 lbs.

Note: Pratt Laboratory, of Atlanta, Ga., on September 14, 1914, made  
 a 24-hour test to determine the ammonia in the crude gas, and  
 reported per ton 5.62 lbs.

## RECENT TAR ANALYSES.

	Tar from seal tank or wash box	Tar from lower seal or trough		Tar from P. & A. extractor 9-18-14	
	9-7-14 Per cent.	9-7-14 Per cent.	9-9-14 Per cent.	Per cent.	Per cent.
Water .....	5.81	2.84	15.54	8.40	0.00
Oil distilling up to 100° F.....	None	None	None	None	None
Oil distilling 100° to 200° F....	None	None	None	None	None
Oil distilling 200° to 300° F....	1.41	0.39	1.45	3.76	4.08
Oil distilling 300° to 400° F....	None	0.63	None	0.30	0.32
Oil distilling 400° to 500° F....	3.52	3.87	None	20.16	21.84
Oil distilling 500° to 600° F....	4.29	6.95	6.36	5.60	6.07
Oil distilling 600° to 700° F....	15.42	20.36	8.30	4.68	5.07
Residue above 700° F.....	69.55	64.96	68.35	57.10	62.62
Insoluble in carbon disulphide..	28.79	27.41	26.09	20.35	22.06

Three of the 7 months during 1913, small streams of water  
 were sent through individual standpipes, one-half of the stand-  
 pipes being equipped with upper and lower seals.

The above results were gotten from a cheap grade of coal. The cost of coal carbonized per 1,000 cu. ft. of gas made, average for the first 7 months of 1914, 26.36 cents. The same coal was used last year.

As we operate without seal, there can be no doubt that some gas is saved on this account. The candle-power and thermal value have shown a gratifying increase. The general improvement in ammonia results is probably due to a number of causes, but at least our standpipe system has not proven detrimental to the ammonia yield, and it possibly is responsible for some of the improvement shown.

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#### THE DEBROUWER CHARGING AND DISCHARGING MACHINE.

For the information from Salem, the Committee is indebted to J. S. Tudbury, and from St. Louis, to J. L. Eigenbrot. The latter article was very much abbreviated due to lack of space, and to the belief that the general principles of the DeBrouwer apparatus were covered by the Salem description.

##### *Salem, Mass.*

*Combined Charging and Discharging Machine.*—The purpose of the combined DeBrouwer charging and discharging machine, as built by the Bartlett Hayward Company to consolidate both operations of discharging and charging in an efficient manner has been successfully accomplished in the type of machine used in the Salem plant. It has made possible the economical use of horizontal through retorts of 20 ft. length for small plants of 600,000 daily capacity and more.

A brief description of the complete machine and more detailed description of the mechanical features follow.

The entire machinery, consisting of ram, centrifugal charger, weighing hopper, scales, tank for cooling water for ram, and electrical motors, are mounted on heavy structural steel truck on 4 car wheels having a wheel base of 9 ft. 3 in. The tracks are 9 ft. 3 in. apart, and the entire space covered by the machine is 120 sq. ft. The figures are given to show the compactness with which the machine was designed without sac-

rificing "accessibility" of the various parts. It is compact but not crowded. The height of the structural frame depends upon the style of benches used. With our bench of 9's, the machine is 14 ft. high.

The machine is built with a main truck frame to which is suspended by heavy chains an inner frame construction on which is built the discharging and charging machinery. The position of the inner frame is dependent upon the height of retorts to be charged. The traverse of the entire machine is accomplished by means of a 10 horse-power motor. A simple clutch utilizes the same motor to raise and lower the charging frame.

The discharging machine is simply designed, and consists of a steel frame, oval in shape, inside of which the ram links coil themselves. The ram is made of links with a smooth bottom wearing surface, the top being designed as a toothed rack into which meshes the driving pinion of a series wound motor. The head is of cast iron of the general shape of the retort, and easily detachable.

The electrical control of this motor is through a master switch and operating relays. A throw of the master switch is all that is necessary on the operator's part. The relays control the resistance and the motor, protecting it from overloads when starting or operating. A circuit breaker is provided which opens on heavy overload and resets itself when circuit is off. In addition, fuses are provided in the main circuit. A limit link is provided to stop the ram at a predetermined position. This permits leaving a core of coke in the discharge mouthpiece. A quenching stream of water plays on the ram and links during its passage in the retort. This is also under control of the operator.

The charging machine consists of a 1,300 lb. weighing hopper and Howe indicating scales, a telescopic chute connecting the hopper with feeder rolls, and a motor driven endless belt.

The coal is taken from overhead bins, weighed and fed directly onto the charging belt through the feeder rolls. The

travel of the belt depends on the speed of the driven motor. This is varied by a mechanically operated rheostat. A set of gears so designed as to change the resistance of motor gradually, is driven by a chain from the motor. A toothed segment is provided by which the rate of deceleration can be changed, by merely shifting the position of the spindle.

At the beginning of the operation, the motor is at full speed with a belt travel of 42 ft. per second per 20 ft. retorts. The gears are engaged and the belt slows down gradually to 18 ft. per second in 30 seconds. For the small charge the first speed is 42 ft. per second and the reduction to slow speed occurs in 15 seconds. This change in rate of charging is accomplished by a simple change in the tooth segment. By it, it is possible to charge from 600 to 1,300 lbs. and obtain a level charge as a result.

The success of any charging machine depends upon the laying of a predetermined charge in a level manner. The DeBrouwer machine lays the charge in a level manner and has laid 70 lbs. to the running foot of retort in the Salem retorts, 20 ft. x 16 in. x 26 in.

The success of the DeBrouwer charger depends on two things:

- 1st. Regulation of flow of coal onto the charging belt.
- 2nd. Variation of speed by mechanical means.

The feeder rolls permit a constant flow of coal and the mechanical rheostat accomplishes the speed variation. The operator starts the motor, opens the coal valve and sets the rheostat and the machine does the rest. The result is a charge well and quickly laid. No attention or consideration has to be given to the way in which the coal is feeding. The feeder rolls makes that factor constant. The "human" element is eliminated.

The electrical apparatus is quite simple in view of the work which it does. It is well designed and amply protected from dust and moisture. Three 10 horse-power motors are provided, one for the traverse of the machine and hoisting of the

inner frame, and one each for the charge and ram. Each motor is operated by magnetic switches and relays. The master switch for each is located in front of the operator within easy reach. The relays are mounted on the back of the main frame in dust protecting asbestos lined boxes. All moving wires are enclosed in B. X. armored cable. No trouble has been experienced as yet in the electric end.

The principal feature of the machine of the Salem type is the consolidation of control and operation of the ram, charger and traverse upon one platform, and in such a manner as not to require high grade men. The machine man acts as shift foreman, looks after proper oiling of all machinery and operates the machine. He is responsible for the safe operation of the house. The day machine man is responsible for heat conditions of the benches. With two mouthpiece men, it is possible to operate 3 benches of 9's completely, taking care of the standpipes, cleaning furnaces, charging producers, etc.

The elimination of one man per shift without increase of investment is a valuable consideration for a small plant.

The speed of operation is not so essential in the small house as in the large house. With this machine, however, any requirement for speed can be met. The position of the charging mouthpiece and the ram is so fixed that the operations of ramming of one retort and charging of another can go on at the same time, or one can overlap the other.

The speed of the ram at present is 1 ft. per second and the charge of 1,100 lbs. is laid in 15 seconds. A good operator can ram and charge the 6 retorts in 15 minutes, allowing ample time to open and shut lids, charging producers and cleaning of carbon from the ends of the retorts.

The Salem plant has 3 benches of 9's, 20 ft. through, with provision for 3 more. The combined DeBrouwer machine answers the purpose in an efficient manner. It is simple, effective, speedy enough and reliable. Our retort labor, while running but 2 of the present 3 benches, is comparable to a larger house. Considerable of this saving is due



to the concentration of the machine work into one operator who can be obtained at a low figure. This has been made possible by the mechanical success of the DeBrouwer combined machine.

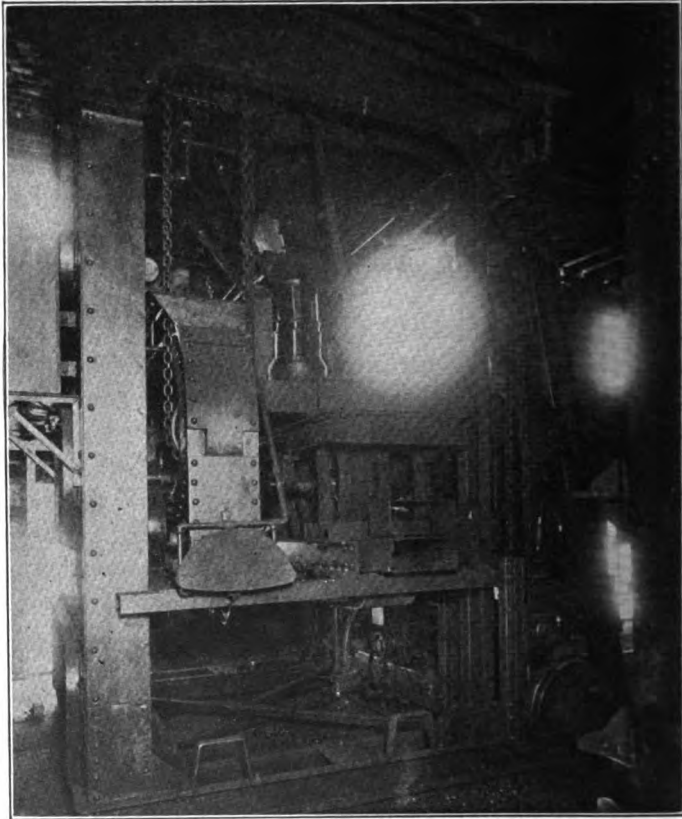


Fig. 28.—DeBrouwer combined machine showing ram head and case, charging wheel and weighing hopper.

Fig. 28 shows charging frame in position for charging on second level of retorts. This shows ram case and head, also weighing hopper and charging wheel.

g. 29 shows operator's platform with controls covering  
plete.

*St. Louis, Mo.*

*parate Charging and Discharging Machine.*—A charging

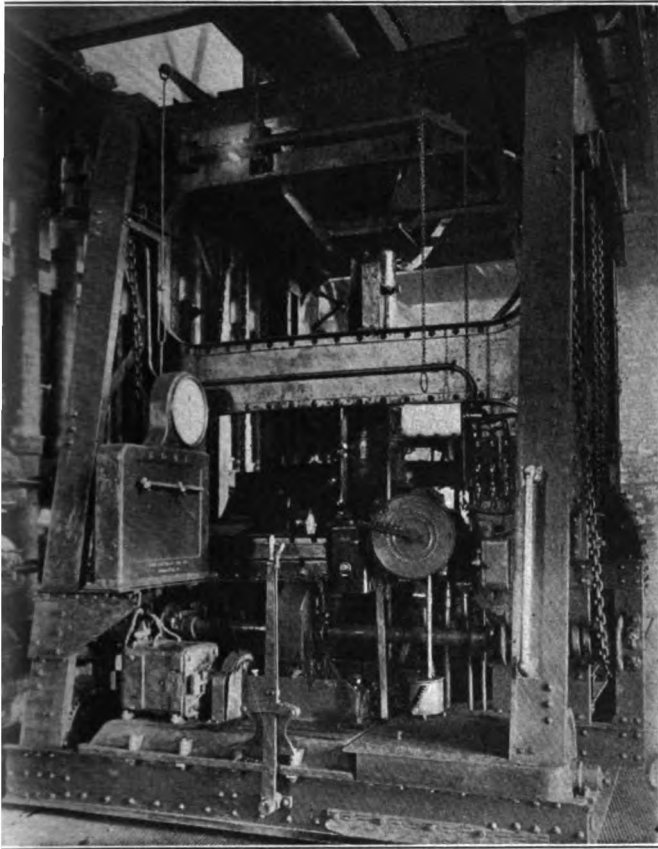


Fig. 29.—DeBrouwer combined machine—Operation platform.

hine (Fig. 30) and a discharging machine (Fig. 31) are  
, operating satisfactorily at the Station B plant of the  
lede Gas Light Company.

A "Stopper" man is not needed at this plant, since about 16 in. of coke are left at the discharging end of the retort and the lid is closed before the retort is charged. Since the retorts are 16 ft. long and the charge weighs 1,200 lbs., it

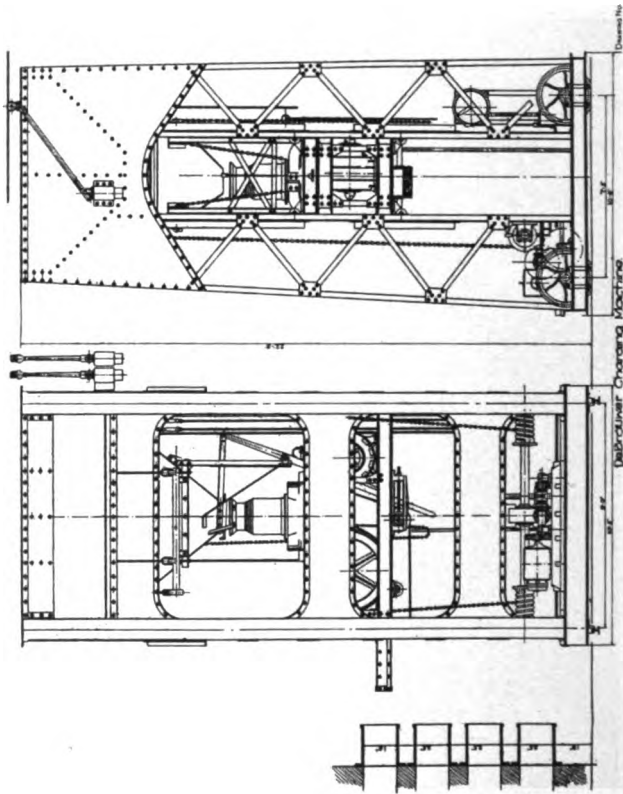


Fig. 30.—DeBrouwer charging machine.

follows that the actual weight of coal per foot of retort will be 1,200 lbs. divided by 14 ft., equals 85.7 lbs. per foot. Thus the coal is brought to within a few inches of the iron mouth-piece on the charging end of the retort, but since all the coke is not discharged, this portion which is not entirely carbonized, is left at the discharging end as a stopper for the coal to be

charged against, and it is at this point where carbonization is completed, eliminating entirely the possibility of poor coke, due to black end.

The carbonizing periods are 8 hours in duration, one stack

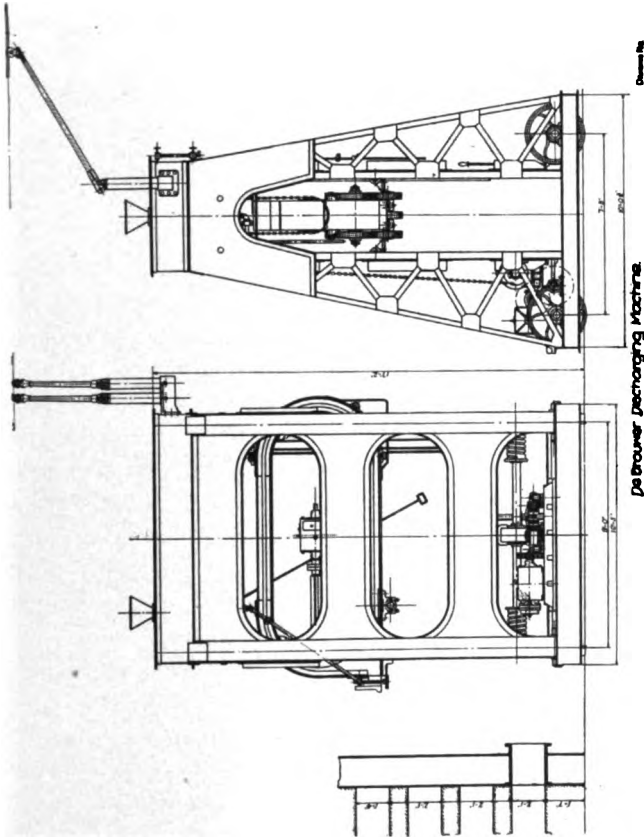


Fig. 31. ---DeBrouwer discharging machine.

of 8 benches being charged each hour, and these 16 retorts are easily charged and discharged in from 15 to 20 minutes.

The belt at the beginning of the charge is traveling at a speed of about  $33\frac{1}{2}$  ft. per second and about 20 ft. per second at the end of the charge.

The wide range in the capacity in these charging machines is

very apparent from the fact that a charge of 85 lbs. per foot of retort is now being laid, and on past occasions the charge has been as high as 89 lbs., and as low as 45 lbs. per foot.

The total current consumption for both charger and discharger is about 0.287 kw. hour per ton of coal carbonized.

The time required in actually laying a charge of 1,200 lbs. is about 21 seconds.

The time required for ramming the retort of coke is about 20 seconds.

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#### REPORT OF THE DIDIER-MARCH COMPANY.

*By G. A. Balz.*

The general principles underlying the design of the Glover-West system of continuously-operating vertical retorts were set forth in the last report of this committee. During the period intervening since that date, some alterations have been made in the design of the apparatus tending to increase the gas producing capacity of the benches, and to further simplify the duty of the retort house operators. These latter improvements were confined to the standpipes, upper mouthpieces and collecting mains to provide greater facilities for the removal of any heavy tar that might, under certain conditions, tend to accumulate when carbonizing certain coals.

Within the past 12 months installations of Glover-West benches were completed and placed in operation at Fitchburg, Mass., and Pawtucket, R. I., the former consisting of one bench of 8 retorts, and the latter comprising 4 benches of 8 retorts each; the two installations being designed for a capacity of 250,000 cu. ft. and 1,000,000 cu. ft. daily capacity respectively.

Fig. 32 shows the latest installation at Fitchburg, and Fig. 33 the Pawtucket installation, with provisions made for future extension. Fig. 34 shows the charging stage and upper mouthpieces being installed at Pawtucket.

An installation of 4 benches of Glover-West retorts is now rapidly nearing completion at Portland, Me.

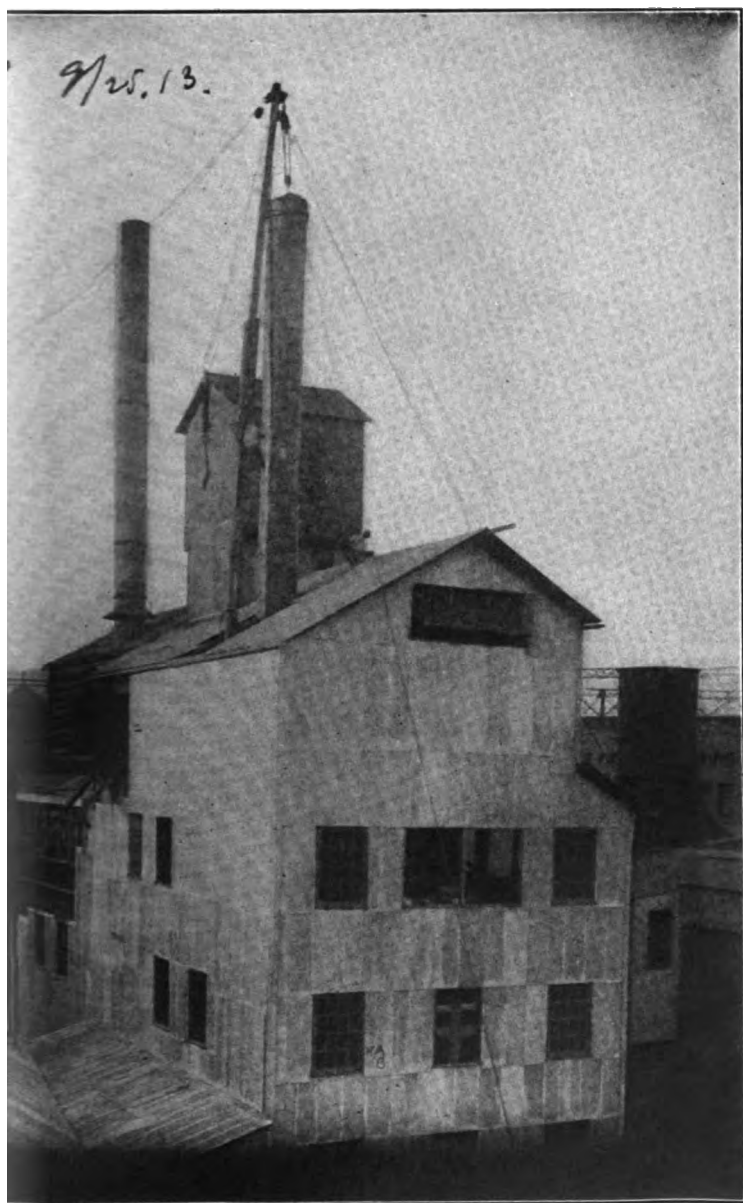


Fig. 32.—Vertical retort house, Fitchburg, Mass.

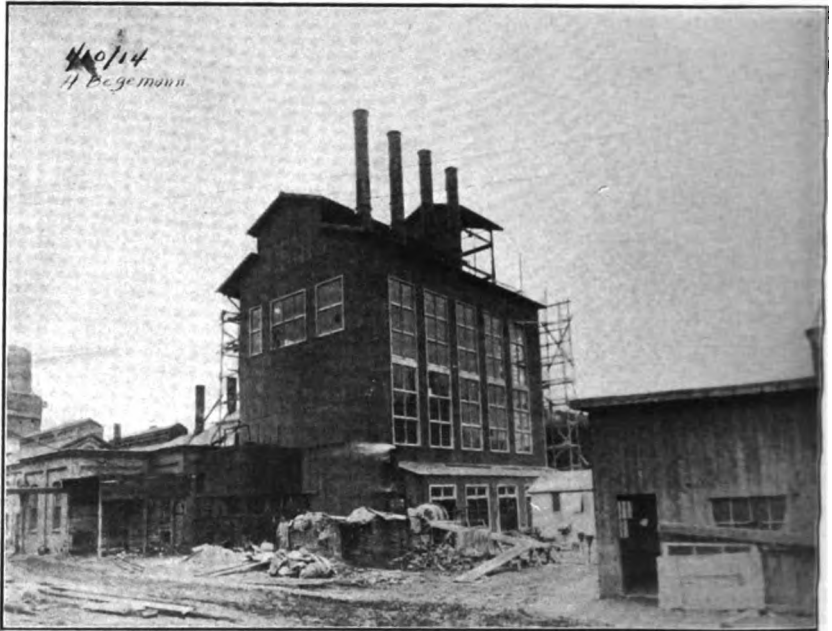


Fig. 33.—Vertical retort house, Pawtucket, R. I.

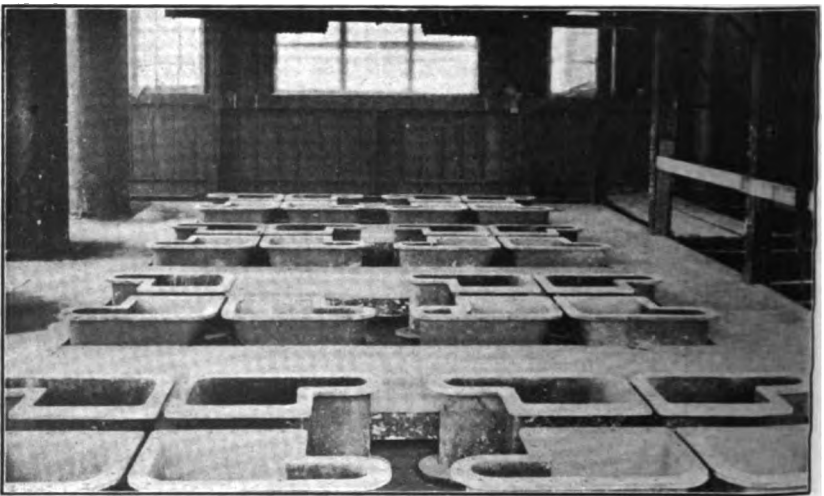
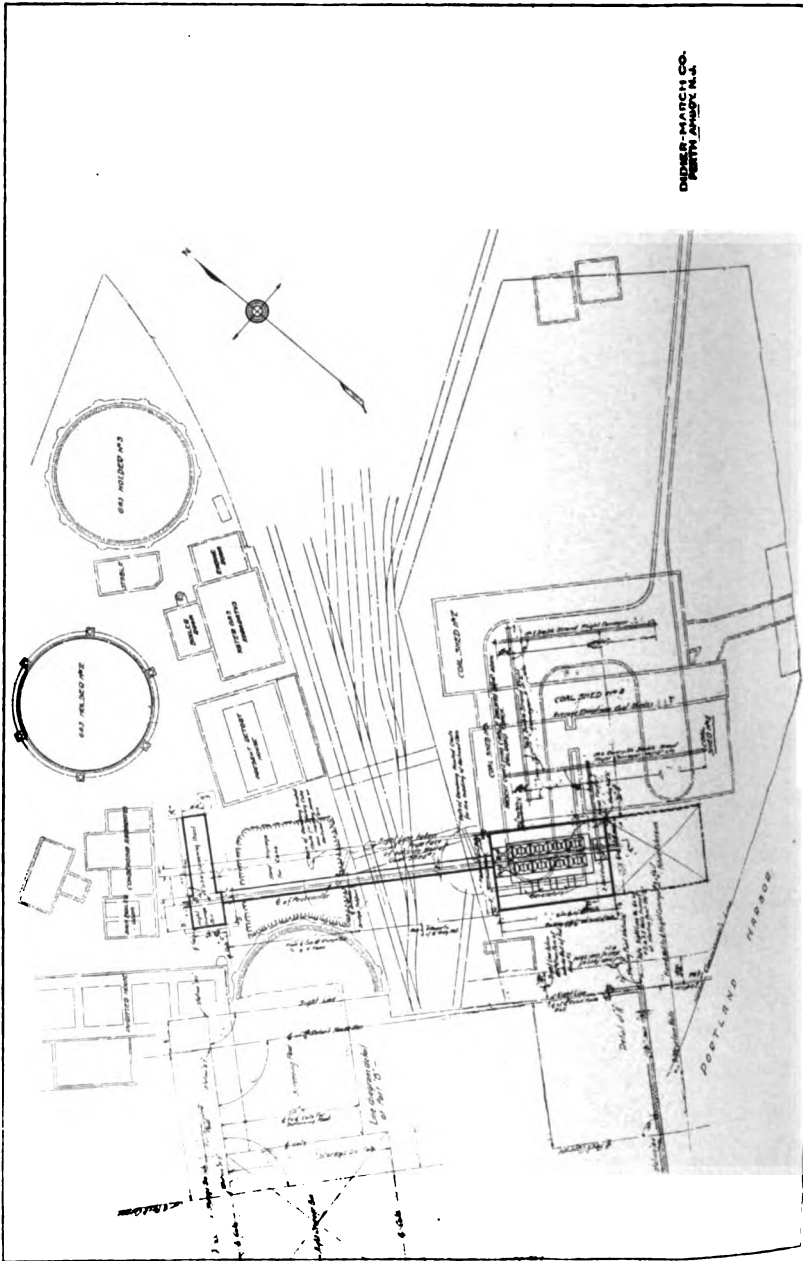


Fig. 34.—Charging stage and upper mouthpiece, Pawtucket R. I.







DIYER-MARCH CO.  
PORTLAND, ME.

Fig. 35. — Plan of works, Portland, Me.

Figs. 35 and 36 indicate an elevation and plan respectively of this Portland plant, including, in addition to the carbonizing apparatus, a complete coal and coke handling equipment with

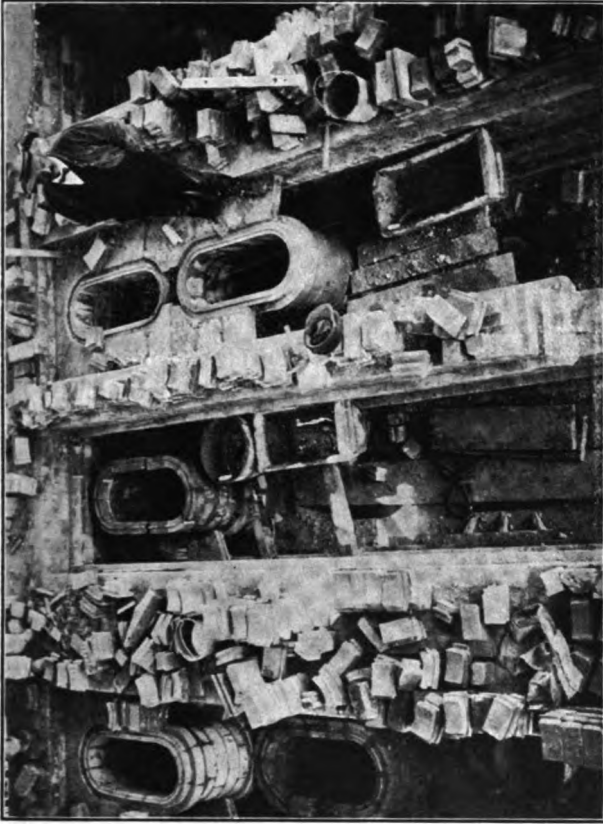


Fig. 37.—Lower portion of Glover-West vertical at Portland, Me.

coke storage and screening and sizing plants. Owing to local conditions, it was found necessary to provide transportation facilities for the coke produced, over the 60 ft. railroad right-of-way of the local terminal company, whose tracks bisect the plant. Provision has been made for the convenient and rapid loading of coke into railroad cars and locomotive tenders, as

it is an established fact that the coke is an efficient and economical locomotive fuel. Particular attention has been given to the provision of means for the accurate determination of the economical result of operation of the benches.

Fig. 37 shows clearly the construction of the lower portion of the retorts where they pass through the regenerative flues.

An economizer has been installed for the efficient recovery of all waste heat not extracted in the recuperation of the secondary air.

An installation now in course of construction at Springfield, consists of 6 benches, divided into 2 units of 3 benches. Each of these units is constructed immediately adjacent to the present retort house, containing benches of inclined retorts. The vertical retort installation is designed along such lines that future connection of the 2 units can be made by the construction of additional benches on the site now occupied by the inclines. When ultimately completed, continuous verticals with a total daily capacity of 1,500,000 cu. ft. will be installed on an area now occupied by inclines of 1,000,000 capacity with a considerable area still unoccupied.

As in the instance of the Portland installation, two units of economizers will be provided at Springfield.

It may be of interest to remark that the new vertical retort units are being constructed without in the slightest degree interfering with the operation of the present inclines.

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#### REPORT OF THE ISBELL-PORTER COMPANY.

*By J. S. DeHart, Jr.*

Since writing the last report on the continuous carbonization of coal in vertical retorts, new plants have been built and set in operation at Holyoke, Mass., Derby, Conn., Brockton, Mass., and Schenectady, N. Y.

The retort house at Holyoke has a skeleton steel construction covered with metal lath and concrete. The house is 62 ft. 5 in. wide by 77 ft. 3 in. long, and will have a capacity for 1,500,000 cu. ft. of gas per day when completely filled. The

ent house has 6 benches each of a nominal capacity of 100 cu. ft. per day, with room to duplicate. The retorts are oval in cross section, made of solid clay rings, arranged 4 to a bench. Two retorts in any bench may be closed to take the fluctuations in the send-out. Fig. 38 shows general design of this installation.

The second Derby installation has a nominal capacity of 100 cu. ft. in 4 benches, and is practically a duplicate of

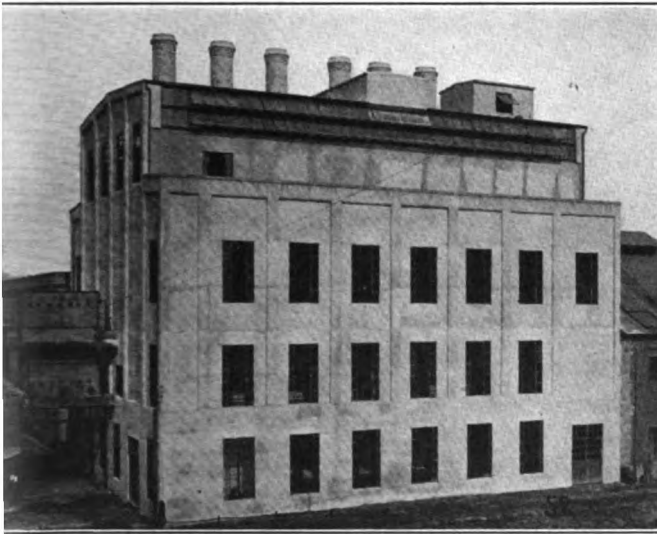


Fig. 38.—Vertical retort house at Holyoke, Mass.

old house, except that the retorts are made of sectional blocks. The extended house contains 8 benches and is 10 ft. 0 in. wide by 120 ft. 0 in. long. The coal is crushed and graded by gravity discharge conveyor in this type of house. The coke is discharged cold without quenching into industrial bins, and raised by platform elevators to yard storage trestle sizing plant.

The labor required to operate a plant of this type making 1,000 cu. ft. of gas per day, consists of a top man to charge

the magazines above the retorts, and two men to discharge the coke from the hoppers at the bottom of the retorts of each shift. The bottom men also take care of the furnaces. A man is required for 2 or 3 hours each day to deliver coal from storage or cars. Fig. 39 shows the original Derby installation.

The Brockton house consists of 4 benches of 250,000 cu. ft. each. Each bench has 4 rectangular ovens or retorts built of

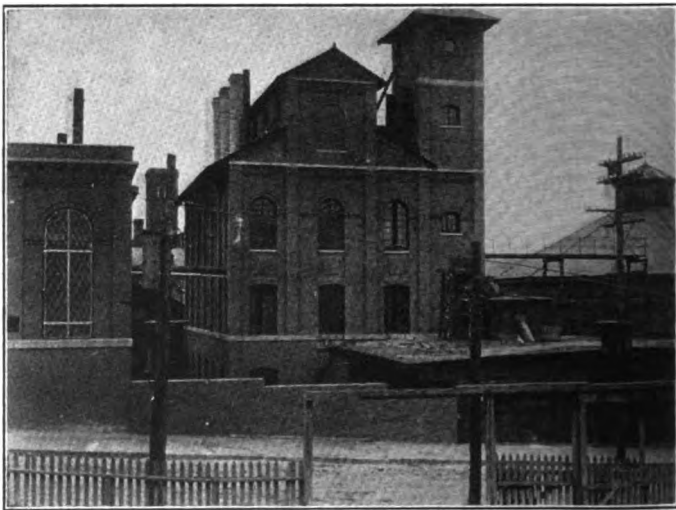


Fig. 39.—Vertical retort house at Derby, Conn.

section blocks. Dampers are arranged so that one or more retorts may be used at a time. The house is 34 ft. 0 in. wide by 85 ft. 0 in. long, and is of substantial brick construction.

The Schenectady plant is similar to the Brockton installation except that 5 benches of a total capacity of 1,250,000 cu. ft. are installed. The coal and coke conveying plants for these two installations consist of 24 in. x 24 in. Peck carriers encircling the house and coke plant. Coke is discharged cold without quenching from 2-hour hoppers under the ovens

directly to the conveyor, and elevated either to the bunkers above the producers or to the coke plant. The coal is taken from a track hopper to a crusher, where it is broken to 2 in. or smaller. It is delivered to the Peck carrier at one end of the house, and elevated to 48-hour bins above the retorts. Coke and coal are weighed on a Merrick scale at the top of the house and recorded on separate counters.

The labor to operate a plant of this type making 1,000,000

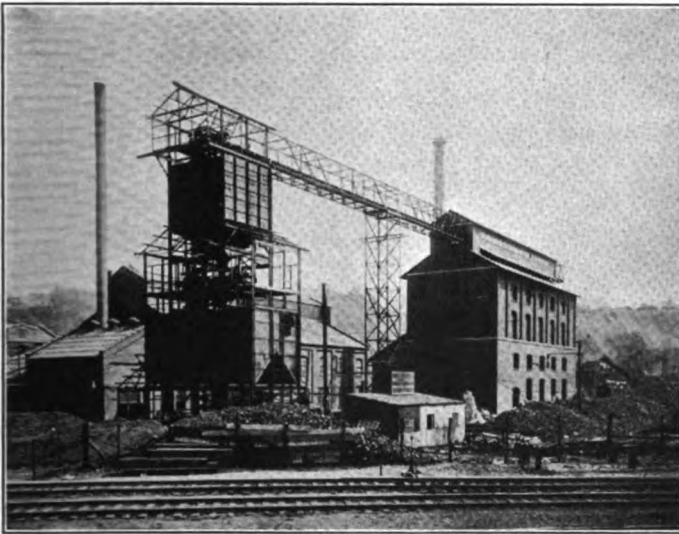


Fig. 40.—Vertical retort house at Schenectady, N. Y.

cu. ft. of gas, consists of a top man to charge the magazines above the retorts, one man to discharge the coke from the hoppers at the bottom of the retorts on each shift, one conveyor man and one furnace man on the day shift. A man is required 3 or 4 hours each day to take coal from storage by locomotive crane or directly from the railroad cars.

The Schenectady plant is shown in Fig. 40, in which the space between the coke plant and retort house is used for yard

storage, the coke from which may be reclaimed into the Peck carrier. The houses are free from smoke and steam, due to the cooling of the coke before discharging. There is *not* the ordinary wear and tear on machines and conveyors, which is unavoidable in discharging hot coke.

One is impressed with the value of present sites for the manufacture of coal gas on account of the small ground space required and the absence of steam and dust of the open end retort systems.

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REPORT OF THE UNITED GAS IMPROVEMENT COMPANY.

*By J. H. Taussig.*

For the information that follows I am indebted, in the case

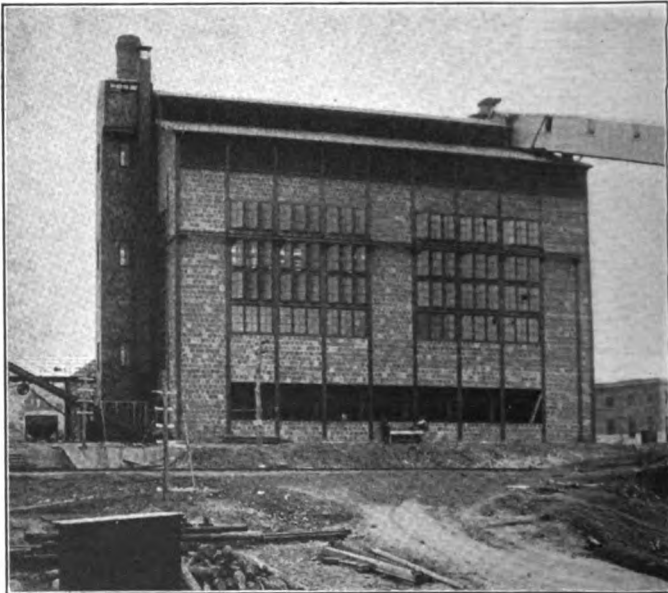


Fig. 41.—Vertical retort house at Fall River, Mass.

of Fall River, to Mr C. W. Hunter, of the Stone & Webster

gineering Corporation, and in the case of Hartford, to Mr. E. Lockwood, of the Hartford City Gas Light Company.

### *Fall River Verticals.*

*General Description of Plant.*—The 1,000,000 ft. coal gas nt recently completed by the Stone & Webster Engineering rporation for the Fall River Gas Works Company, is the t unit of an ultimate development which provides for a sible daily capacity of 8,000,000 ft. of coal gas and 8,000,000 of water gas. It is located on Mt. Hope Bay, about 2 es south of the city, and has both rail and deep water con-tions.

All the buildings of the plant, except the retort house, are fireproof brick construction with flat concrete roofs. The ort house (Fig. 41) is built of 6 in. hollow tile supported on steel framework with cement tile roof. By the use of wind iss construction above the operating floor, the wind pres-res on the building are carried to the foundations through e building frame, leaving an unobstructed space for the nch equipment. The south and east sides of the building, to ich the future units will be added, are lined with temporary ling.

### *Carbonizing Plant.*

Briefly, the carbonizing plant designed and erected by The nited Gas Improvement Company, consists of 7 benches, ch containing 9 retorts, arranged in rows of 3. Each tort is about 18 ft. long, 12 in. x 22 in. at the top, and 18 in. 30 in. at bottom (inside dimensions). The retorts, with the ies surrounding them, are supported on steelwork about ft. above the ground level; just back of them are located e recuperator sections. In the rear of each bench, the pro-cers extend from the ground level to a height of approxi-ately 13 ft. They are charged from the top with hot coke / means of buggies traveling on rails over the charging door. ee Fig. 42.

In the framework of the roof, over the benches and in line



with the retorts, is hung a steel suspension bunker running the length of the battery and having a capacity of 30 hours coal supply. There is a pocket in the bunker over each bench for coke breezes. Under the bunker and over the retorts, an

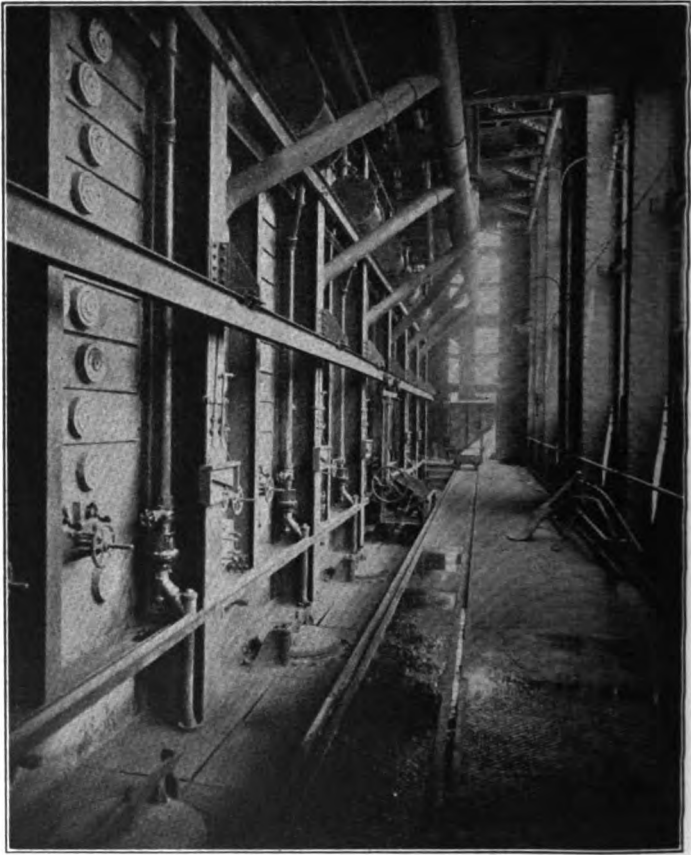


Fig. 42.—Producer charging floor, Fall River, Mass.

electrically operated larry, with 3 coal hoppers and 3 breeze pockets, travels on rails hung from the steel framing. (See Fig. 43.) Under the retorts, a discharging car, built of cast

iron plates hung on a steel frame, is operated by hand on rails at the ground level.

The bottom doors of the retorts are of cast steel and are operated hydraulically from a platform about 4 ft. above the



Fig. 43.--Operating floor, Fall River, Mass.

ground level and in front of the retorts. The retorts are handled in rows of 3. In discharging, the upper mouth-piece is opened, the discharging car pushed under the retorts

to be dropped and the lower doors are opened from the discharging platform, allowing the coke to drop into the car from which it is taken away by conveyor as described later. In

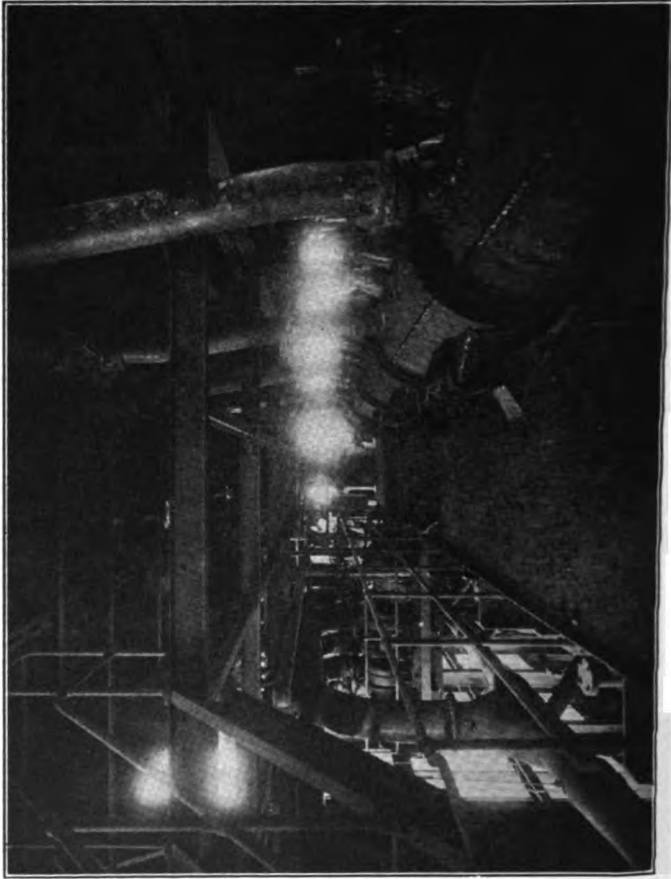


Fig. 44.—Hydraulic main platform, Fall River, Mass.

charging, the lower doors are first closed, the charging larry is filled with breeze and coal from the overhead bunker and run over the retorts. About 3 cu. ft. of breeze is first dropped into each retort and then the charge averaging about 1,700

per retort is deposited. The coal is weighed by a scale attached to the larry before each charge.

Each bench has an individual hydraulic main with self-cleaning pocket. (See Fig. 44.) The gas from each

of retorts is led to the hydraulic and a 12 in. off-take is from each hydraulic to the retort house header, the pressure in which is controlled by a retort house governor at the end of the battery. Each hydraulic has a weak liquor feed, an overflow valve and balanced system of tar removal. The benches are usually operated at about an even seal. By means of a flushing tank and system, the seal is raised on each bench as it is charged.

In the heating system, the  $\text{CO}_2$  return system has been adopted. The producer gas passes from the producers first to a horizontal combustion chamber, located about on a level with the bottom section of retort, where secondary air is added and most of the combustion takes place before the gases come in direct contact with the retorts. From the combustion chamber, the gases pass around the lowest retort section and are directed by baffles in a vertical winding path to the top, then downwards through the recuperators and out the stack. Between the valve at the top of the stack and the benches, a bench pipe is taken off which leads to a turbine driven blower means of which  $\text{CO}_2$  and other products of combustion can be drawn in from the stack and forced under the producer grates. A second blower on the same turbine shaft forces secondary air to the recuperators; through a by-pass from this to the outlet of the  $\text{CO}_2$  blower, primary air is mixed with the products of combustion. By means of valves, the mixture of waste gases and air can be regulated so as to control the percentage of  $\text{CO}_2$  in the gases under the grates, and by the variation of this percentage, the temperature of the setting as a whole can be raised or lowered with remarkable accuracy. The blast pipes leading the "primary mixture" to the grates and the secondary air to the recuperators are placed controlling valves, so that the temperatures of the individual benches can

be regulated; Venturi meters are also used to measure the volume of air and gas. There are no inside dampers to handle, and close regulation can be maintained. It is aimed to keep the temperature in the hottest part of the combustion chamber about  $2,450^{\circ}$  F.; in the 30-day test the lowest temperature read with a Wanner pyrometer was  $2,318^{\circ}$  F., and the highest  $2,570^{\circ}$  F, while the average was  $2,443^{\circ}$  F.

There are no water pans in the producers and no steam is used under the grates which are of the shaking type, operated from the front by hand lever. They are shaken about 4 times a day and the ashes raked out. Since starting up the plant on May 3rd, no clinkering or pricking up of the fires has been necessary.

#### *Coal Handling Plant.*

Coal is received in barges which dock at the end of the wharf. The coal handling plant is of the "mast and gaff" type, and consists of a central steel mast from which are swung 2 booms. The upper boom, carrying a trolley and  $1\frac{5}{8}$  yard grab bucket, is extended over the end of the dock when a steamer is being unloaded. Coal is conveyed by the bucket from the hold of the vessel to a steel hopper located in the central mast. Just below this hopper, at a height of about 25 ft. above ground, is swung the second boom carrying a 36 in. belt and tripper; coal from the hopper is fed onto the belt by a reciprocating feeder and discharges into storage or the crusher bin, as desired. Both booms swing completely around the mast so that coal can be stored or reclaimed from any point within the circular area around the base, in which several months' supply will be kept as "emergency storage" which will only be used in event of prolonged delay in delivery. A concrete bin, capable of holding about one and one-half barge loads of coal, is used for "running storage." In ordinary operation, when a cargo of coal is received, the belt boom is placed over the crusher bin and all the coal passed through the crusher, adjusted to break large lumps to 6 in. in size, and conveyed by an inclined belt system on the top of

concrete bunker. Every morning the day's supply of coal the benches is dropped through a valve in the bottom of bunker onto a belt leading to the crusher, set to  $1\frac{1}{2}$  in. and is conveyed by an inclined belt system to the bunkers the retorts. By this plan, the minimum amount of hand- and reclaiming will be necessary and the coal used may be effected from the effects of the weather, except on the comparatively rare occasions of delays in shipment lasting a month or more. The system has a capacity of 100 tons per hour, and electrically operated and controlled.

#### *Coke Handling Plant.*

The hot coke discharged from the retorts drops first into hot coke discharging car, which has an inclined bottom with discharging gate. When the gate is opened by a hand lever, the coke slides into a DeBrouwer conveyor through all cast iron feeding hoppers which distribute an even stream. The conveyor carries the coke to the end of the house and then up an incline to the top of the concrete coke storage bin. From the head of the DeBrouwer the coke is discharged down a chute to the crusher and vibrating screen, passing on way over a 4 in. bar screen. The pieces which fall through the screen are passed along a second chute, over a  $\frac{7}{8}$  in. bar screen to the vibrating screen without passing through the crusher. The crusher, which is of the 2 roll adjustable type, set at 4 in. and all coke passing through it, together with the pieces less than 4 in. which are by-passed around, is sent over the vibrating screen, sized and dropped into the proper bin. The conveyor, crusher and screen are motor driven and controlled from the retort house.

The coke bunker is situated alongside the railroad switch so that coke can be loaded by gravity into railroad cars on one side and wagons on the other. Directly underneath the bunker, chutes fitted with bagging machines are attached. Coke for outside storage is handled by a remote control monorail system with self-tripping bucket, which is operated by one

man from the ground at the bunker. The storage yard is so laid out that wagons can be filled directly from the pile.

Quenching is done after the coke leaves the house and the steam is carried away by a vapor stack. About half way up the incline and directly under the conveyor is located a circular steel bunker lined with firebrick. When the producers are to be filled, the coke from the discharge is not quenched and is dropped through an opening in the bottom of the conveyor into the hot coke bunker, from which it is dropped into cars wheeled to the producers.

#### *Results.*

Ground was broken for the new plant in April, 1913, and on May 3, 1914, the first retort was charged. About two months were spent in adjusting the equipment and general tuning-up, and on July 13th a thirty-day acceptance test was started to establish the guarantees made by the bench contractors. During this test, no unusual methods, which could not be followed in regular operation (such as excessive temperatures in the benches, etc.) were used to increase the performance. An extra force of engineers was employed in checking carefully all of the results obtained. All of the instruments, scales, meters, tanks, etc., used were carefully calibrated just before the test began. Each charge of coal was weighed, a sample taken and its moisture determined, while the average of each day's samples was analyzed in the laboratory. Each buggy of coke charged to the producers was weighed and the fire at the end of the test was brought to the same height as at the beginning. No method of weighing the total coke produced at each charge was available, but 6 tests were made, in each of which the coke dropped from 3 retorts was weighed and screened by hand and the ratio of the coke to the original charge of coal calculated. The candle-power of the gas was measured on a "Sugg D" burner against a standard pentane lamp every hour during the 24. The heating value was determined every 6 hours. Sufficient hygrometer tests were taken to determine approximately the

carbon vapor dew-point. The temperature of the gas was read on a thermometer located in the front of the meter, above the water line, and the volume was read hour. The tar and ammonia were drained into separate and checked every morning.

$\frac{3}{4}$  in. screened coal used during the test contained an large proportion of slack, which probably affected the icies obtained in an unfavorable manner. The average of the moisture analyses made each day as the samples aken showed 2.2 per cent.  $H_2O$ . A portion of all sam-ken were sent to Boston and analyzed with the follow-ults:

	Proximate analyses	
	As received per cent.	Dry basis per cent.
Moisture .....	2.15	
Volatile .....	33.80	34.54
Fixed carbon .....	57.50	58.77
Ash .....	6.55	6.69
	<hr/>	<hr/>
	100.00	100.00
Sulphur .....	1.14	1.16
Average results of the 30-day test are as follows:		
Charged, pounds.....	6,113,728	
$H_2O$ in coal.....	2.20	
Carbonized, in pounds .....	5,979,495	
Total coke to coal, as charged.....	70.6%	
Total dry coke to dry coal.....	+71.6%	
Net pounds coke, as charged.....	848,522	
Bench fuel to coal, as charged .....	13.88%	
Bench fuel to coal, dry .....	14.19%	
Corrected for temperature, barometer and holder (sure) per pound coal, as charged.....	5.314 cu. ft.	
.....	5.434 cu. ft.	
Power on "Sugg D" burner.....	16.71	
Gas made corrected for temperature barometer holder pressure .....	32,491,200 cu. ft.	
Net per pound coal, as charged.....	88.80	
Net per pound coal dry.....	90.80	
Reduced per net dry ton, pounds .....	7.30	
2% $H_2O$ produced per net dry ton, gallons..	14.70	
Specific gravity of gas.....	0.4355	
Dew-point.....	55° F.	



The retort house labor consists of two regular operators on each of two 12-hour shifts. These men charge and discharge the retorts and remove coke, clean standpipes, fill producers, shake grates, decarbonize retorts and clean up operating and discharging floors. For an average of 20 minutes in every 2 hours, a yard man is brought into the house to assist in moving the hand-operated discharging car while the retorts are being dropped. One other extra man is brought in during the periods of decarbonization, which appear to be necessary about every 4 to 6 weeks. It is believed that in future operation can be arranged so as to dispense with this extra help. Other labor is required regularly to fill the overhead bunkers with coal and coke breeze, remove and screen ashes, clean out conveyor trench and hydraulics.

The coke produced from the plant is of excellent structure, good color and of such large size that it is difficult to quench until it has been crushed to size. The quantity of breeze made is noticeably small. The tar is thin and easily handled as it contains only traces of naphthalene. The analysis of one week's sample is as follows:

Specific gravity .....	1.127
Moisture (by volume) .....	3.4 per cent.
Free carbon .....	3.74 per cent.
B. t. u. ....	15,944

#### *Distillation.*

Up to 170° C. ....	8.00 per cent.
170° to 225° C. ....	12.30 per cent.
225° to 270° C. ....	10.30 per cent.
270° to 360° C. ....	23.00 per cent.
Residue .....	48.50 per cent.

The figure given for production of ammonia is the result of analysis and measurement of all the liquor made during the test in a well used only for this purpose. It was checked closely by chemical test for total  $\text{NH}_3$  in the gas leaving the retort house.

*Hartford Verticals.*

This plant, completed in May, 1914, is of the vertical retort type, operated intermittently, installed by The United Gas Improvement Co. (see Fig. 45). It consists of 7 benches of 9

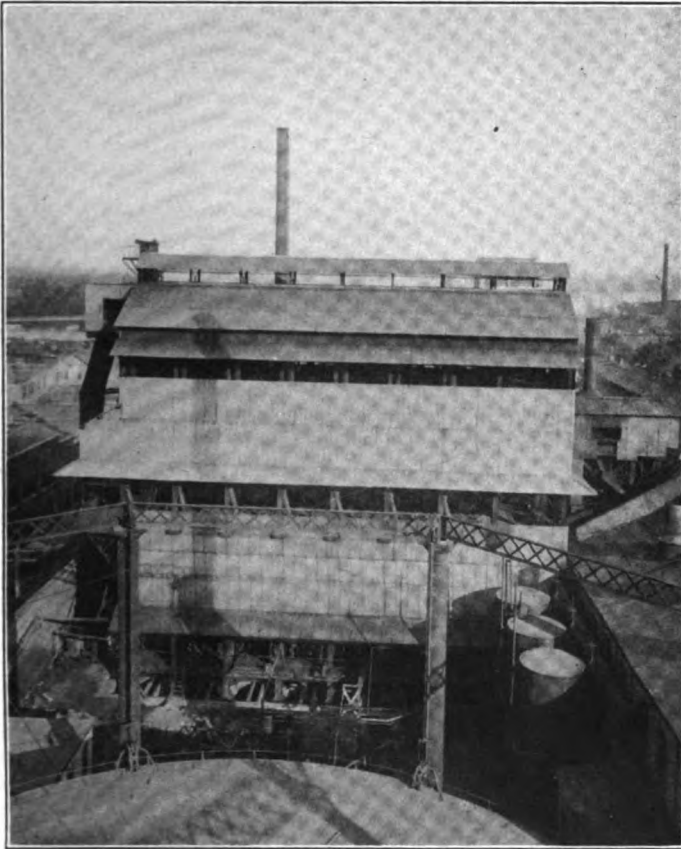


Fig. 45.—Vertical retort house at Hartford, Conn.

retorts each, placed in rows of 3, so that 3 retorts are operated simultaneously. The accessory equipment consists of a producer for each bench, operated under positive pressure by

turbo-blowers located at the top of the retort house, two sets of the usual type of hydraulic main, one at the top and a small one at the bottom of the retorts, coal storage bins above the settings, an electrically operated coal charging car, an



Fig. 47.—Front view of benches, showing furnaces and Venturi meters, Hartford, Conn.

electrically operated car to receive coke from the retorts, a bucket conveyor passing under the benches then up over the top of the coal bins and down again at the other end of the retort house, a brick lined bin to store breeze, a brick lined bin to store hot coke, a shaking screen and quenching table, electrically operated coal handling apparatus and a boiler

ing heat in the waste gases from the settings. See Fig.

ie producers are located in the rear of the benches and provided with shaking grates and designed to be charged hot coke from a hand car, filled from the hot coke storage

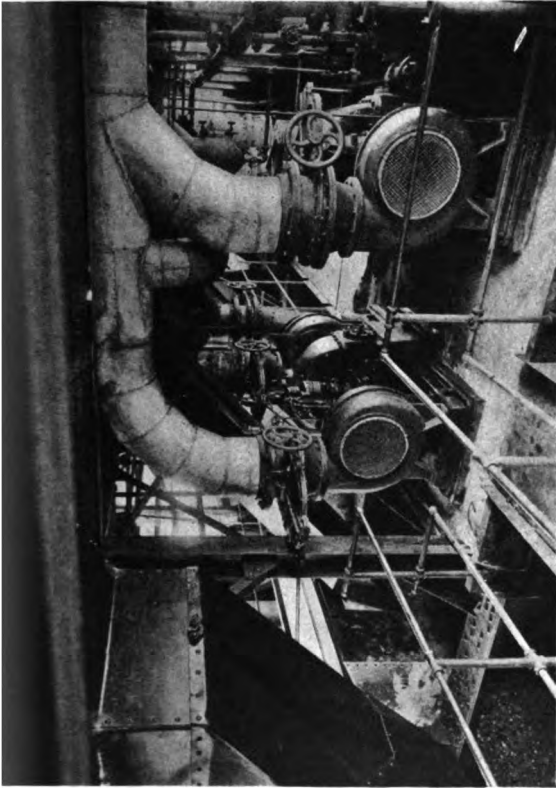


Fig. 48.—Blower equipment, Hartford, Conn.

one end of the furnace charging level. Each bench is 1 with a mixture of air and  $\text{CO}_2$  under the grates and condary air in the combustion chamber at the producer g level. These mixtures are measured by means of meters and are supplied from separate blowers driven ame turbine. (See Figs. 47 and 48). The  $\text{CO}_2$  in the

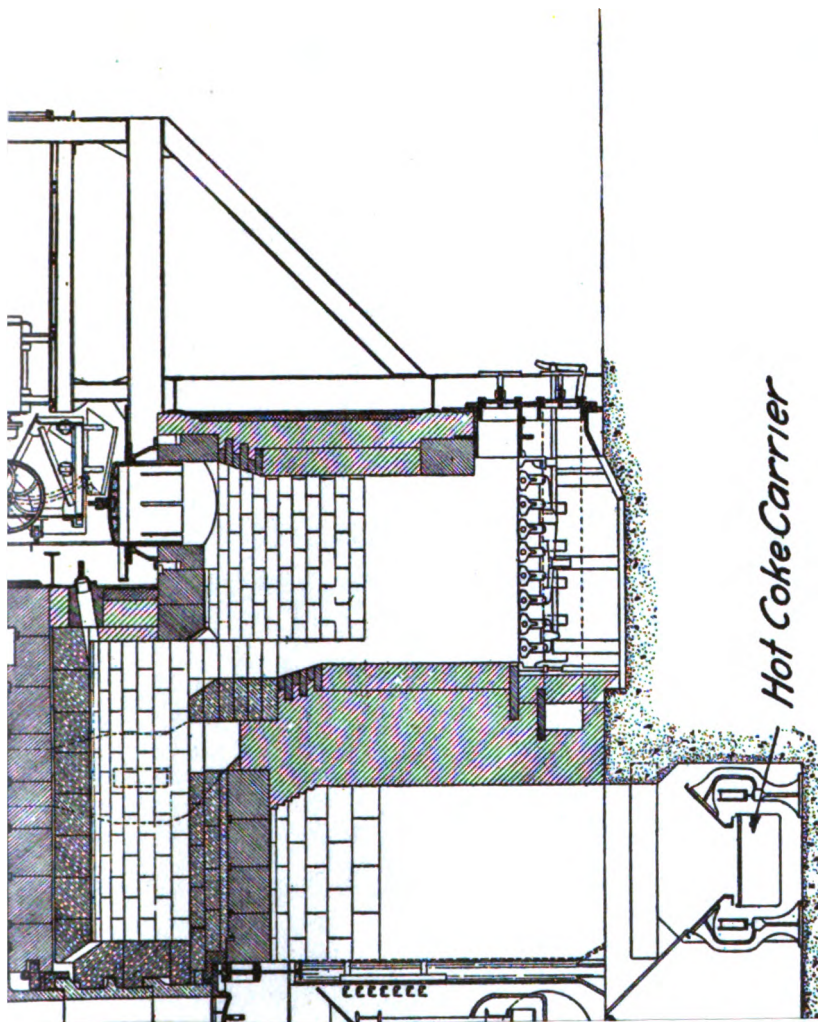
primary mixture is drawn from the waste gas stack at the outlet of the boiler, its proportion is governed by means of the inlet air valve, giving a very flexible method of control.

Each bench has independent upper and lower hydraulic mains, through which weak liquor is kept circulating at all times, the large main on top being equipped with a tar displacement system. There are 3 take-off pipes to each bench, each pipe taking the gas from 3 retorts. A very light seal is carried normally which is increased when retorts are open for charging or scurfig.

Coal storage bins over the retorts are designed to hold sufficient coal for 48 hours operation and contain also smaller bins for the storage of coke breeze, of which a small quantity is dropped in the bottom of the retorts to protect the lower doors. These bins are supplied from the upper level of the bucket conveyor mentioned above, and are emptied through chutes into the coal and breeze charging car, which is propelled electrically the whole length of the retort house, hanging from overhead and collecting current from contact rails. The car has 3 hoppers for coal and 3 for breeze. The volume of coal can be varied by means of baffle plates and is weighed while in the hoppers.

Below the retorts is the hot coke car, of heavy steel construction with cast iron plates. (See Fig. 49). It is provided with a revolving drum at one side, operated by a separate motor so timed as to feed the hot coke into the conveyor at the proper speed. Another motor propels the car and both receive current from contact rails at the side and are operated by means of electric controllers at a distance from the car.

The coal handling apparatus consists of a short apron feeder taking coal from the cars on a railroad siding to a belt conveyor, which runs through a concrete tunnel from the railroad to the plant, passing under two streets, and covering a distance of 700 ft., this was necessary because a railroad siding across the streets was not permitted. The coal is here dumped into a pit, from which it can be removed by the grab-bucket of an



*Hot Coke Carrier*

Hot coke carrier and retorts at Hartford, Conn.



ly operated crane, and stored, or can be carried by apron feeder to a screen and crushed, which deposits bucket conveyor by which it is carried up and dropped overhead bins.

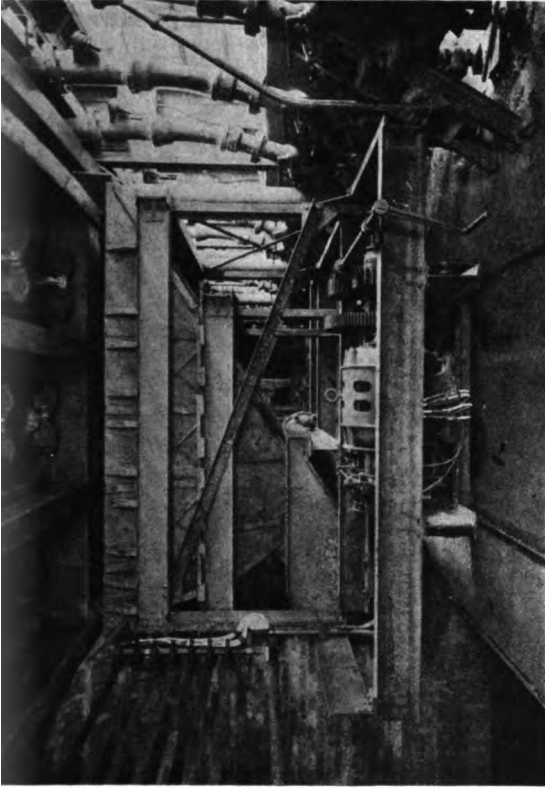


Fig. 49. Hot coke car, Hartford, Conn.

oilier located on the top floor utilizes the heat of the gases from the various benches and supplies steam to pumps and turbines.

Normal operation consists in filling the hoppers of the charging car with crushed coal, which is weighed for each retort, filling breeze hoppers in like manner without weighing, moving car over 3 empty retorts, where first the breeze is



allowed to drop to the bottom and then charging the coal to within about 4 ft. from the top. After a period of about 12 hours, the top doors are opened and necessary cleaning around the mouthpieces and pipes completed, when lower doors are opened and the coke drops into the car below, which feeds into the moving bucket conveyor. This carries it, hot, the length of the retort house and up to the moving screen, which separates the breeze into a bin, from which it can be removed at will. The lump coke continues over the shaking table, where it can be quenched and carried over to a cold coke storage bin or dropped hot into the brick lined hot storage bin, where it remains at a high temperature until emptied into the furnace charging car, in which it is weighed before being charged into the furnaces.

Each bench is provided with a thermo-couple at the top of the recuperator chamber, connected to a common pyrometer. The inlet and outlet of the waste gas boiler are equipped in like manner, so that these temperatures can be read at a glance. Sampling pipes lead from the flues of each bench, from the boiler stack, and from the outlet of the primary mixture blower to an Orsat flue gas analysis apparatus located adjacent to the pyrometer on the retort charging floor. Temperatures in the combustion chamber are read with a Wanner pyrometer, so that this in conjunction with the electric pyrometer and Orsat burette mentioned above, affords an easy means of ascertaining and regulating operating conditions.

A test conducted by the builders in order to prove their guarantee produced the following results, using "Harry B" Fairmount coal, of the following characteristics:

Moisture.....	1.25
Volatile.....	36.60
Fixed carbon.....	55.88
Ash.....	6.27
	<hr/>
	100.00
Sulphur.....	0.876%

Results obtained at test:

Average gas made, 24 hour, 60° F., 30" bar.....	1,132,000 cu. ft.
" yield per lb. (dry basis).....	5.37 cu. ft.
" length of charge .....	11.50 hrs.
" total coke made per ton (dry basis)....	1,357 lbs.
" coke per ton, bench fuel (dry basis) ....	263 lbs.
" candle-power, Argand Sugg D. ....	17.98
" candle feet per lb. dry coal .....	96.63
" B. t. u. per cu. ft. ....	635
" ammonia made per ton (tested at foul main) (dry basis) .....	7.08 lbs.
" tar made per ton coal (dry basis) .....	14.39 gals.
" horse-power developed by waste heat boiler....	95

These results were obtained under conditions of a guarantee test and consequently do not allow for some of the operating conditions, a very important one of which is scurfing.

Normal operation requires the labor of a man on the retort charging floor, and another at the bottom of the retorts. These men drop and charge retorts, clean standpipes, fill furnaces, draw off tar and shake grates. Additional labor is required to draw and screen coke from ash pits, clean hydraulic mains, operate coal conveyor and clean lower pipes and doors while scurfing. There is also a man employed to look after the boilers, turbines and to take hourly readings.

Occasional trouble has been encountered by reason of the failure of carbonized charges to drop. This has been caused by difference in temperature in different sections of the retort, by the accumulation of carbon along the sides, and by the use of damp breeze in the bottom. Lower doors and take-off pipes tend to become fouled easily and are difficult to clean, this causing leaks at the bottom of the retorts.

The coke produced by this plant is of large size, light gray in color, and much harder than the coke produced in horizontal settings.

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#### REPORT OF THE H. KOPPERS COMPANY.

*By C. J. Ramsburg.*

Last year, the report of progress by the H. Koppers Company showed in detail the various types of plants erected by

that organization for supplying coal gas. Since that report, the Koppers' small gas unit has been added, and two plants of this character have been erected in Europe, one at Elbeuf, France, consisting of 6 ovens, and one at Innsbruck, Austria, consisting of 12 ovens, Fig. 50. It is proposed to erect this type

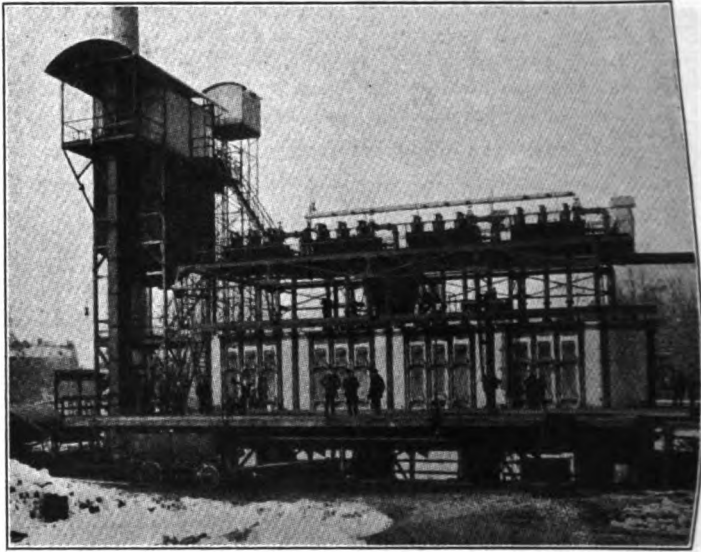


Fig. 50.—Kopper's small coal gas unit at Innsbruck, Austria.

of plant for the smaller coal gas installations in America, having a capacity of from 500,000 to 1,000,000 ft. per day.

The following results were reported by the Directors of the Innsbruck plant in 1913:

Operating statement for the Koppers' chamber oven gas plant at Innsbruck, Austria:

Coking time, hours .....	24
Coal charged per year, net tons.....	12,665.50
Volatile matter in coal, per cent.....	32
Gross coke produced, net tons.....	9,120.98
Tar produced, gals. ....	169,490
Ammonia sulphate produced, net tons.....	128.75

## Production per net ton of coal gasified:

Gas at 30 in. 60° F. sat., cu. ft.....	11,024
Coke, lbs. ....	1,440
Tar, gals. ....	13.38
Ammonia sulphate, lbs. ....	20.30

## Coke balance:

Coke produced per net ton of coal, lbs....	1,440
Coke used for under-firing, lbs.....	254

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 1,186

## Gas results at 30 in. 60° F. sat.:

Per lb. of coal, cu. ft. ....	5.512
B. t. u. per cu. ft. ....	595
B. t. u. per lb. of coal.....	3,279.60

*Description of Operation of Koppers' Small  
Coal Gas Unit.*

Fig. 51 shows a cross section of the ovens and a ground plan of the plant. Lump coal is dumped from the railroad car into the coal boot and crusher (4 and 5), whence it is elevated by the conveyor to the overhead bin, which has a capacity to run the ovens 24 hours. From the overhead coal bin, the coal is run into the charging larry (3) which is pushed along the battery until it comes over the oven to be charged. In the meantime, the oven doors have been removed, the coke charge has been pushed by the electrically operated pusher (1) on the coke quenching bench, where it is cooled. The doors having been replaced, the coal from the larry car is allowed to run quickly into the oven through the oven charging holes at the top, being leveled simultaneously by the electrically operated leveler bar on the pusher machine (1). The larry car is then run to one side, the charging hole covers are replaced and the valves opened to the gas collecting main. This entire operation requires about 15 to 20 minutes.

In a plant of 10 ovens, 5 ovens are charged in the early morning and 5 in the late afternoon.

Coke for the gas producer is pushed from the quenching bench directly into charging doors of the producers. These

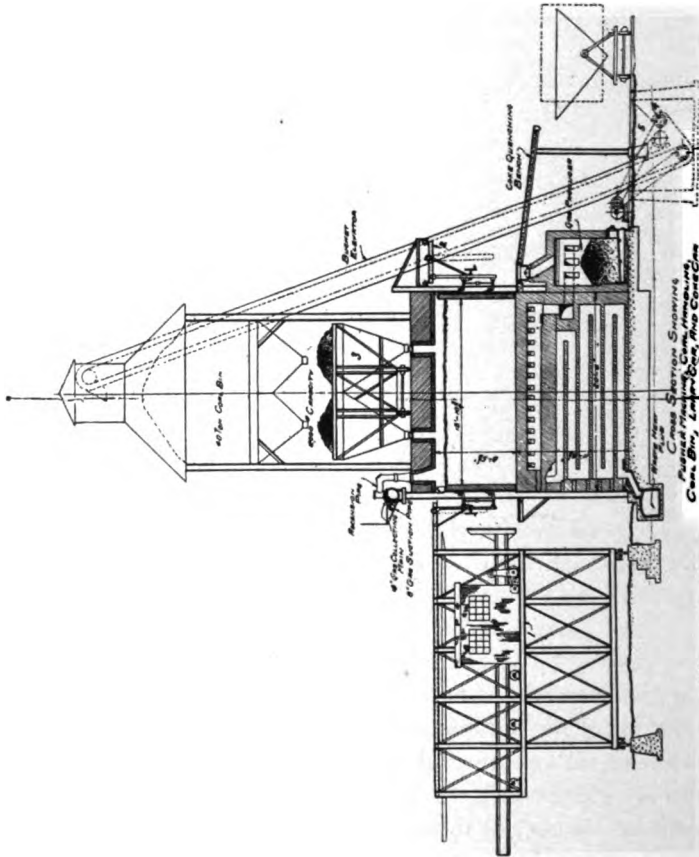


Fig. 51. - Cross-section of Kopper's small coal gas unit.

producers are so designed that the slag may be readily removed at the bottom.

The gas delivered into the collecting main is drawn by the exhauster through a cooler, where it is cooled and a large portion of the tar condensed. It is then pushed through a tar extractor and a reheater into a saturator, where it is made to bubble through a saturated solution of ammonium sulphate containing about 5 per cent. free sulphuric acid, precipitating the ammonia as solid crystalline sulphate of ammonia which is subsequently removed and dried.

The gas passes through the purifiers, which remove the sulphur, and it is then clean and ready for distribution. An ammonia still is used for the recovery of ammonia in the condensate. This is returned to the gas and recovered as sulphate.

The plant is complete for making either illuminating or fuel gas and for the recovery of all by-products.

From the standpoint of gas manufacture, two features are of interest.

1st. The beginning of the construction of 56 Koppers' by-product coke ovens for the Laclede Gas Light Company, of St. Louis.

2nd. The starting of the by-product coke oven plant for the Maryland Steel Company, supplying gas to the Consolidated Gas Company of Baltimore.

#### *St. Louis Plant.*

The original plant contracted for at this point was for 56 13¼-ton cross regenerative coke ovens. A change has been made in this, in that the battery will be "combination ovens," instead of straight coke ovens. This means that the construction will be altered so that producer gas may be used to effect the carbonization, if at any time it seems desirable to do so.

When operated as a gas oven plant, if producers should be later installed—on first class gas coal, operating on 18 hours coking time—this plant would have a daily capacity of ap-

proximately 10,500,000 cu. ft. It may be also so arranged that any oven may be made to operate as either a coke oven or a gas oven, so that the production of gas may be varied nearly 100 per cent., from all-coke ovens to all-gas ovens.

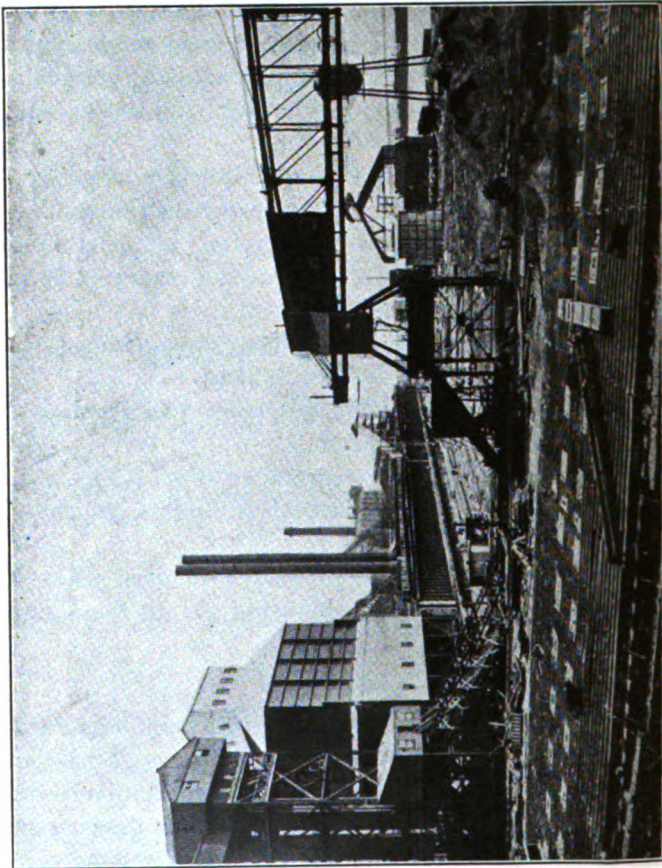


Fig. 52. -Coke plant of Maryland Steel Company.

Construction of this plant is under way, and it may be expected to be in operation in the spring of 1915.

*Maryland Steel Company's Plant.*

This plant (Fig. 52) consists of 120 13¼-ton cross regen-

erative coke ovens, erected on 2 batteries, operating to make coke for the steel company's blast furnaces. It is equipped to separate the gas into rich and lean. A small benzol plant is operated to remove a portion of the benzol from the lean gas and to add this to the rich gas for increasing the candle-power.

The plant is also equipped with the Koppers' direct process for the recovery of ammonia.

On account of general business conditions, only one of the batteries has been started, and this is operating on about 25 hours coking time, there being no necessity for a larger coke production.

The operation has been successful beyond expectation, and a yield of rich gas amounting to nearly 5,600 ft. of 630 B. t. u. per net ton is secured, measured at the end of a 12-mile pipe line at Baltimore.

(Mr. Spencer read an abstract of the report.)

THE CHAIRMAN: This is a report of the highest excellence, and bears evidence of a great deal of very patient and complete work. Mr. Hunter?

MR. C. W. HUNTER (Boston): Some additional data on the Fall River test, which was worked out after the original paper was printed, may be of interest.

The average analysis of four samples of gas taken during the test is as follows:

	Per cent. by volume
CO <sub>2</sub> .....	1.2
CH <sub>4</sub> .....	0.9
H <sub>2</sub> .....	4.1
O <sub>2</sub> .....	1.0
CO .....	6.9
CH <sub>4</sub> .....	28.8
H <sub>2</sub> .....	51.9
N <sub>2</sub> .....	5.3
Candle-power .....	17.2

The figure given for production of ammonia is the result



of analyses and measurement of all the liquor made during the test in a well used only for this purpose. It was checked closely by a chemical test for total ammonia in the gas leaving the retort house.

An approximate weight distribution of the various products obtained per 2,000 lb. of coal as received, is given below. On account of the difficulty and expense of getting exactly comparative data this distribution is not exact, but it is believed to be close enough for practical purposes:

	Pounds
Gas .....	352.00
Tar .....	132.00
Coke.....	1,405.00
Ammonia .....	7.14
Sulphur.....	7.60
Water.....	100.00
	<hr/>
	2,003.74
Less extraneous nitrogen (approximately) .....	22.40
	<hr/>
	1,981.48

In this connection, I think that the recommendation of the Committee that definite methods of making carbonizing tests be formulated and stamped with the approval of the Institute, is to be encouraged. Many of the figures that we read about carbonizing tests are taken in so many different ways that it requires long study to really know what each figure means. A good deal of useless discussion would probably be cut out if definite rules, similar to the boiler tests series of the American Society of Mechanical Engineers, and other similar societies, were gotten out by the Institute, and every carbonizing test was carried out along these lines.

THE CHAIRMAN: Any other gentleman?

MR. R. C. CONGDON (Atlanta, Ga.): On page 497 the operating results shown were not figured on a dry basis; if so figured, the yield per pound would be 5.1 cu. ft. and the candle-feet 81.95. The coal we are using is, for the most part, washed, and is obtained at low cost.

MR. W. J. MCGURTY (New York): I have a question to

ask Mr. Congdon regarding the tar analysis on page 497. It would seem that in operating the scrubber with a spray, the free carbon, or the material insoluble in carbon disulphide, would be less in the upper than in the lower seal. It shows differently, but there may be a mistake in reporting.

MR. CONGDON: Most analyses show the carbon content higher in the lower seal; just why in this instance the reverse is the case, I am unable to say.

THE CHAIRMAN: Gentlemen, this being a sectional meeting, bringing us in a more familiar relation with each other, affords all of us here, who have any difficulty of any kind in carbonization, opportunity to get an effective reply from this well informed Committee. I hope that if any engineer or member has any questions, that he will give it to the Committee at once while everything is fresh in his mind.

MR. V. VON STARZENSKI (Schenectady, N. Y.): Our plant of Woodall-Duckham development has only been in operation two months; consequently, we are not in a position to give any figures or any experience.

THE CHAIRMAN: Mr. DeHart, have you anything to say?

MR. J. S. DEHART (Newark): I cannot add anything to the paper, but I do want to congratulate Mr. Taussig upon his being able to give two sets of figures as complete as these are, before your meeting here to-day. He has been a pioneer in intermittent vertical installation, and I take off my hat to him.

THE CHAIRMAN: Mr. Taussig, I think you ought to explain.

MR. J. H. TAUSSIG (Philadelphia): Every one can see what it is, and I am sure he can soon have his plant running just as well as ours, if not better. I should like to say that it is very important indeed that we should do what Mr. Hunter has suggested and get a standard set of rules for making tests on coal gas plants. We have had, during the past two months, to make two guarantee tests. These we wanted as accurate as possible for our own information. We made these tests the way we thought was best, but it would have been more satis-

factory had we a standard method, sanctioned by the American Gas Institute. I should like very much to see a set of rules made, and I should like to make a motion that the matter be placed either in the hands of the Carbonization Committee or that a committee be appointed to formulate rules of tests that can be followed in guarantee work as well as other work, so that the figures which may come before this Institute will comply with those rules. We sometimes have marvelous figures reported to this Committee that seem almost impossible to get, and if we had such a set of rules, we would avoid this.

MR. W. H. GARTLEY (Philadelphia): I think that suggestion of having a committee go to work to standardize methods is one of the most important that we have before us. It is time now that the Institute became more thorough, that it went into the question of standardization more completely than it ever has done before. It is not a new idea. In the Chemical Section, as you know, that thing is being worked out. This year, it seems to me, is an excellent year for just that sort of thing. We are now carrying on four Sections. Every room is filled. That is due, probably, to having rooms too small, but it shows the interest that is going to be taken, and the work that is going on along just that line. By standardization, we will simplify the work in the future very much and become efficient.

MR. WALTON FORSTALL (Philadelphia): In the October *News*, the Technical Committee recommended that next year there be a Committee on Physical Tests. This Committee will endeavor to standardize such tests.

MR. C. J. RAMSBURG (Chicago): If you will look back through the Institute PROCEEDINGS, you will find that almost this same discussion took place in Detroit, in 1909. I think that Capt. McKay himself recommended this, and that Mr. Searle and Mr. Gartley talked upon its importance. There was a Committee appointed, but the Committee did not get up the specifications as intended. It got up a certain set of

specifications, but it did not go into chemical tests and the fundamental principles of how the different tests should be conducted. This year the Carbonization Committee proposed to do that, but was told it was not in its province. If this can be brought about by the appointment of a committee of people who make these tests and know how to make them, and want to know how to make them, it seems to me that we can get somewhere.

MR. W. G. AFRICA (Manchester, N. H.): I move that a vote of thanks be extended to this committee for its very excellent work, and that its recommendation be referred to the Board of Directors.

The motion was seconded.

THE CHAIRMAN: You have heard the motion, which includes, when passed, the thanks to the Committee for its work, and particularly directs the attention of the incoming Board of Directors to this subject of standard tests, and implies a request that this work be provided for through a suitable committee. The motion is duly seconded. Those in favor please say aye. (Ayes.) Mr. Spencer and the Committee, the section thanks you very heartily for your splendid paper.

The next scheduled paper is: "Carbonization in Bulk—Koppers' Ovens," by Mr. C. J. Ramsburg, of Chicago.

### CARBONIZATION IN BULK—KOPPERS' OVENS.

The purpose of this paper is to set before the Institute the fundamental principles involved in the carbonization of coal in bulk, its advantages, its methods, the results of plants in operation and a general summary of the state of the art in its relation to the supply of gas for urban use.

It was our purpose primarily to bring before you the results achieved in the great European plants operated by this method and to draw attention to the benefits to be derived from the use of the method in America. We also intended to supplement this with the results of a test made by the Maryland

Steel Company in ovens used for the manufacture of high quality coal gas. We still have these purposes in view, but in addition have seen fit to draw to your attention the operation of by-product coke plants. This has been done because the growth of this industry bids fair to make the gas supply for many large centers of population originate in these plants, and we feel that information in regard to them will not be without interest. We believe that up to this time there has been presented before either the American Gas Institute or the American Gas Light Association, but one paper which has made more than indirect comment of these sources of gas supply.

The coke oven has been the source of domestic gas supply for many years both in this country and Europe, but it was not until 1908 that this principle was applied for the production of such gas in gas ovens with independent producer plant. It was common practice to use a portion of the coal gas as the source of heat, but the plant erected that year in Vienna was designed to use a coke oven in which the carbonization was conducted by producer gas made in a central producer plant, thus allowing the entire coal gas production to be available.

*Central Producer Plant with Cleaned Preheated Producer Gas versus Built-in-Producers.*—In this Vienna plant, the fundamental difference in operation compared with ordinary coke oven practice, consisted in heating the ovens and conducting the carbonization, not with a portion of the gas produced from the coal, but by means of gas secured from an outside source, liberating all the gas from the coal distillation for distribution and sale. This was an innovation. Such had been the practice for many years in coal gas retort plants, but it at once became evident, that in order to use the general principle of oven methods as against retort practice, the built-in-producer commonly used in that practice would not be suitable for operations on a large scale, therefore, the method was conceived of building the heating system on broad lines and using the most advanced methods of making the producer gas.

perience in regenerating producer gas had proved the fact producer gas contained such large quantities of fine dust particles, that it was absolutely necessary to remove these impurities by washing the gas, which in turn necessitated cooling as in the scrubbing process. Such a gas when cold, even the secondary air heated to a temperature of 2,000° F. hardly sufficient flame temperature to effect the carbonization properly. There was, however, enough heat being wasted in the outgoing products of combustion to effect the preheating of the gas as well.

The scheme at length boiled down to the following proposition:

- a) To secure the gas by the most efficient producer which would also utilize the fine coke and breeze—low grade fuel.
- b) To equip this installation in such a manner that it could be operated continuously without interruption, and to use a mechanically revolving grate which would maintain even fire conditions and discharge the ash continuously. This meant constant production of gas of uniform quality.
- c) To extract the heat from this producer gas in a waste heat boiler—enough steam being secured to more than operate the mechanical features of the producer plant and supply steam to the grate.
- d) To scrub the gas clean of dust particles.
- e) To conduct the gas to the oven battery under pressure.
- f) To divide the regenerators in such a way that secondary air could be preheated under one oven and producer gas under the adjacent one; each separate regenerator being so divided as to make the gas and air supply independent for each oven, and to have a heavy wall which supports the upper construction and division of air and gas.
- g) To admit the gas to the base of the regenerator through a valve cock, so that the amount going to each oven could be regulated and adjusted.

This scheme was carried out entirely, proving an immediate and lasting success. It is the backbone of the success of the process.

In comparison with this arrangement, the "built-in" producer is used in retort practice. This type of producer, if carefully analyzed, has many glaring faults. In the first place, it is usually so designed that it is exceedingly difficult to discharge the hot coke into the producer so as to insure a level fire, and one of uniform texture. This means an over-use of a portion of the fire and the resulting gas is of very variable constitution. If this feature is to be overcome, it is usually necessary to use cold coke.

The fire temperature is such that in certain zones fusion of the ash occurs and interference with free, uniform flow of primary air takes place, so that the amount and quality of the gas produced varies from time to time.

The producer is charged with fresh fuel at long time intervals, making the depth of fire a constantly varying one which also means a variation in quantity and quality of gas.

Natural draft is depended upon for combustion. This means that any interference with the primary air supply by means of accumulation of ash or clinker, or any weakness in the fire due to poor fuel distribution, immediately reacts upon the secondary air supply in a *reverse* manner for efficiency, a decrease in producer gas corresponding to an increase in secondary air, thus making it impossible to preserve a high and uniform efficiency of combustion.

Another defect of the "built-in" producer is the large amount of carbon removed with the ash. This is due to poor conditions of combustion in the base of the fire. It is not an infrequent occurrence to find that the ash from such a producer contains 25 per cent. of carbon.

The "built-in" producer takes no account of the dust passing from the fire into the combustion chamber and into the flues. This dust is of a composition, similar to the ash of the coal used, and for the most part has a fusing temperature between 2,200° F. and 2,600° F. It does not take much imagination to picture what a force for deterioration in the fire brick material and lessening of conductivity, this means.

Little study has yet been made and little data are known of these effects, but we are of the opinion that the gas fraternity will wake up to a realization of its damage before long.

The "built-in" producer uses for the most part, hot coke. Even with the hot coke, there are few plants in operation where accurate records are kept, showing less than 300 pounds of coke used per net ton of coal carbonized.

Let us see what a comparison in thermal efficiency between the "built-in" producer and the central producer plant as built in connection with Koppers gas ovens, will disclose.

Euchene in his classic analysis of the efficiency of a coal gas bench showed the following distribution of the heat necessary to carbonize a pound of coal.

Distribution of B. t. u.'s necessary to carbonize one pound of coal—*deduced from Euchene*:

Total heat required 1,843 B. t. u.'s.		B. t. u.
	Flue gas losses .....	602.5
	Heat in gaseous vapors .....	330.0
	Sensible heat of coke .....	443.0
	Radiation .....	495.0
	Formation of vol. comp. endothermic	36.0
	Decomp. of coal .....	466.0
	Sensible heat of ash .....	19.0
	A total of .....	2,391.5

From this must be deducted 549 B. t. u.'s due to exothermic reactions in the formation of the gases, leaving 1,843.5 B. t. u.'s net.

An examination of this table will show that of this but 726 B. t. u.'s per lb. of coal passes through the retort, made up as follows:

	B. t. u.
Gaseous vapors .....	330
Sensible heat of coke .....	443
Endothermic reactions .....	36
Decomposition of coal .....	466
	1,275

From this deduct heat formed in exothermic reactions

549
726

The heat lost:—

	B. t. u.
Flue gases .....	603
Radiation .....	495
Clinker .....	19
Total .....	1,117



Thus in securing the benefit of 726 B. t. u.'s, 1,843 B. t. u.'s are expended, showing an efficiency of approximately 39 per cent.

This was on a "stop end bench" employing a net furnace consumption of 296 lbs. of coke per net ton of coal, and run with a high percentage of  $\text{CO}_2$  in the outgoing flue gases. This means a bench fuel account of 14.8 per cent.

There are few retort coal gas plants of any type, either in this country or abroad where furnace accounts are properly kept which show more efficient operation.

Please bear in mind one other important point in Euchene's figures. Little allowance was made for excess air or escaping uncombusted products in the chimney gases. Such conditions may be preserved in test conditions, but the average coal gas plant has large losses from these causes. Also, that little allowance was made for carbon in the ash refuse, inasmuch as it was picked and returned to the furnace, presumably. This too is the source of large losses in the average plant.

In comparison with this efficiency under perfect condition, of 39 per cent. on the "built in" type using 14.8 per cent. of furnace fuel, let us see what the efficiency is of the central producer and the Koppers regenerative gas oven.

In September and October, 1912, Dr. Karl Bunte in connection with the Experimental and Educational Committee of the German Gas and Water Association conducted a thorough and complete test on the Koppers Gas Oven Plant at Leopoldau, Vienna.

The following is taken from his report:

"The gas oven battery consisted of 72 ovens divided into blocks of 9 chambers each. Five blocks were used in the test. These ovens are 33 ft. 2 in. long and have an average width of 20 in.

#### "PRODUCER PLANT.

"For the production of producer gas, for heating the ovens, there are 12 producers of the Kerpely-Marischka system. The producers are equipped with steam boilers which pro-

duce steam for the machinery, for blowing the air, purifying the gas, operating the boiler feed pumps and blowing steam under the producers. There is still an excess of steam left which is used in the ammonia stills, and for the production of electric power. The fuel charged into the producers consists of small coke and breeze. This fuel was weighed on railroad scales which had been tested and calibrated. The producer gas passes through disintegrators where it undergoes a thorough washing by means of water, in order to remove all of the dust carried in the gas.

"Regarding the efficiency and heat balance of the producer plant and the ovens, very exact tests were made.

"The coal which was carbonized in this plant consisted mainly of a mixture of Ostrauer and Drombrauer coals.

"The coke is pushed out by a pusher machine and conveyed by a bucket conveyor. The coke produced is large in size. The coke separation permits five different sizes of coke to be separated. The coke separation has a connection with the central producer plant for coke supply to the latter.

"The coke for the central producers was taken from the coke storage bin, and was a mixture of coke and breeze made from the different coals as described.

"The size of the coke was determined by sieve test and carefully taken from average air dry samples.

#### SIEVE TESTS.

Sizes	Day	Sept.	18-19	1st. test			2nd. test	
				19-20	20-21	21-22	25-26	26-27
0-11 mm.....			12.0	10.7	7.4	13.5	9.7	7.6
11-25 mm.....			27.7	29.9	46.9	40.6	53.5	52.4
Above 25 mm. ....			60.3	59.4	45.7	45.9	36.8	40.0
Per cent. by weight.			100.0	100.0	100.0	100.0	100.0	100.0

Sizes	Day	3rd. test				
		Sept. 30 Oct. 1	Oct. 1-2	Oct. 2-3	Oct. 3-4	Average
0-11 mm. ....		13.5	7.3	10.0	10.70	10.20
11-25 mm. ....		40.9	46.1	51.4	52.95	43.3
Above 25 mm. ....		45.6	46.6	38.6	36.35	46.5
Per cent. by weight.....		100.0	100.0	100.0	100.0	100.0

**"HEAT BALANCE OF THE GAS PRODUCERS.**

"The coke charged into the producers contains the usual amount of moisture and the producers are operated by blowing in cold air and steam. The greater part of the heating value of the coke is found in the form of producer gas. The amount of gas can be calculated from its carbon content, determined by analysis and from the amount of carbon contained in the coke.

"Part of the carbon in the coke is found again in the ash."

Professor Bunte found the following data in regard to the producer gas plant.

Introduced	Mill calories	Per cent.
Calories in coke .....	381,230	97.93
Calories in steam under grate .....	11,690	2.97
	<hr/> 392,920	<hr/> 100.00
<i>Returned:</i>		
Calories in gas form .....	312,330	79.48
Heat contents of the gas .....	2,032	0.52
Heat contents of water vapor in gas .....	7,245	1.86
Water evaporated .....	60,969	15.51
Carbon in ashes .....	2,512	0.64
Carbon in flue dust .....	1,345	0.34
	<hr/> 386,433	<hr/> 98.35
Not accounted for .....	6,487	1.65
	<hr/> 392,920	<hr/> 100.00

This shows that from 381,230 million calories introduced as coke, there were returned as cold, uniform producer gas ready for the oven battery 312,330 million calories, all operations having been performed without resorting to any outside source of heat or power.

*This shows a net efficiency of the central producer plant of 81.9 per cent.*

There was then made a thorough, accurate and complete examination into the amount of heat used in carbonizing the coal.

The tests showed that in order to carbonize 966,250 Kilo's of coal (2,130,214 lb.), there were required 527,525 c. m. of gas (18,629,000 cu. ft.) having a heating value of 1,216 calories per cubic meter (136.7 B. t. u.'s per cubic foot).

So that each kilo of coal required 663 calories in the form of gas (1,194 B. t. u. per lb. of coal.)

We have seen in Euchene's analysis of heat distribution that the amount of heat necessary for the carbonization of one pound of coal was 726 B. t. u.'s.

I see no reason to believe that this should be more or less in a gas oven than in a coal gas retort. Using this figure, we find:

Heat necessary to carbonize one (1)

lb. of coal = 726 B. t. u.'s.

Heat in producer gas necessary = 1,194 B. t. u.'s.

Heat efficiency of ovens = 60.8 per cent.

Heat in coke necessary to produce 1,194 B. t. u.'s in

producer gas  $\frac{1,194}{81.9}$  1,458 B. t. u.'s.

Overall heat efficiency of carbonizing system:

$$\frac{726}{1,458} = 50 \text{ per cent.}$$

against 39 per cent. on the horizontal stop end retort plant working with no loss in ash pan or chimney, other than those which pertain to ideal conditions.

Translating this into carbon, we find that in the retort using 1,846.5 B. t. u.'s per pound of coal, this corresponds to

$$\frac{1,846.5 \times 2,000}{14,544} = 254 \text{ lbs. carbon per ton}$$

or per 100 lbs. of coal = 12.7 lbs.

The producer operated gas oven uses

$$\frac{1,458 \times 2,000}{14,544} = 2,005 \text{ lbs. per ton}$$

or per 100 lbs. = 10 lbs. of carbon.

It will be of further interest to make a comparison between these heating systems from a standpoint of difference in cost of fuel.

Let us assume that in a retort coal gas plant in America with normal gas coal, 1,325 lbs. of gross coke is secured per net ton, of which 300 lbs. is used in the producer, leaving 1,025 lbs. net coke and breeze for sale. Of this, 10 per cent. is

breeze, so that we have *net* 103 lbs. of breeze and 922 lbs. of coke.

If coke is worth \$4.00 and breeze \$1.50 per net ton, we find—assuming 10 per cent. of the total coke as breeze—that had we used none in the producer, the coke and breeze would have been worth:

$$\begin{array}{rcl} 133 \text{ lbs. of breeze @ } \frac{\$1.50}{2,000} & = & \$0.10 \\ 1,192 \text{ lbs. of coke @ } \frac{\$4.00}{2,000} & = & 2.38 \\ \hline \text{Total} & & \$2.48 \end{array}$$

Since, after producer fuel is deducted, there remain

$$\begin{array}{rcl} 103 \text{ lbs. of breeze @ } \frac{\$1.50 \text{ per ton}}{2,000} & = & \$0.077 \\ 922 \text{ lbs. of coke @ } \frac{\$4.00 \text{ per ton}}{2,000} & = & 1.844 \\ \hline \text{Total} & & \$1.921 \end{array}$$

We find that the cost of fuel per ton carbonized was 56¢.

In the retort plant, we find that 0.4 lb. of steam was used under the ash pan per lb. of combustible =

$$254 \times 0.4 = 61.60 \text{ lbs. per ton of coal.}$$

If steam is worth 40¢ per net ton, this steam would add a further charge of  $61.6 \times \frac{40}{2,000} = 1.232\text{¢}$ , making a total cost of producer gas without labor of

$$56 + 1.23 = 57.23\text{¢.}$$

With the supposition that 10,500 cu. ft. of coal gas is secured per net ton of coal, the cost of producer fuel per M cu. ft. will be

$$\frac{57.23}{10.5} = 5.45\text{¢ per M.}$$

On the central producer plant, the amount of breeze made will be 120 lbs. per net ton. This will all be used in the producers.

Assuming the 200 lbs. of carbon to be the amount necessary to use in the producers per net ton, assuming that the

breeze has 84 per cent. carbon and the coke 87 per cent., we find that we will require per net ton of coal carbonized:

$$120 \text{ lbs. of breeze, costing } 120 \times \frac{150}{2,000} = 9\phi$$

and

$$115 \text{ lbs. of coke, costing } 115 \times \frac{400}{2,000} = 23\phi$$

$$\text{Total cost } 32\phi$$

Assuming that all steam will be made by the producer plant, the cost of furnace fuel will be  $\frac{32}{10,500} = 3.04\phi$  per M.

This shows a saving in furnace fuel alone in the two systems of 2.4¢ per M feet of gas produced.

This is equivalent to a net saving of  $57.23 - 32 = 25.23\phi$  per net ton of coal.

*Plant investment does not enter into this saving, inasmuch as the complete gas oven plant does not cost any more than a retort plant, and the plant must be regarded as a whole. The cost of operating a producer plant of this character from a labor standpoint shows a further saving, but this does not seem to be the place to go into this phase, other than to point to the fact that producer gas manufactured "in bulk" is cheaper than the large number of separate units.*

From the foregoing exposition of the comparison between "built in" producers and the central producer plant, I believe that I am justified in saying that if the carbonization in bulk rested alone on this feature, it would be far in advance of any other coal gas system.

So much for the principles involved in the production of heating gas. Let us turn now to the principles involved in the production of the coal gas itself, and see where the gas oven stands in relation to fulfilling the ideal conditions for the production of maximum gas yields of high quality, the conservation of the by-products, the conditions of labor, repair and up-keep costs.

### EFFICIENCY OF GAS PRODUCTION.

Each pound of coal used in making gas, represents in itself unlimited possibilities. To use a rather mixed metaphor, each pound is a "Pandora's box" from which flies out at the opening of the lid, perhaps troubles in vast quantities for the operator of coal gas plants, but certainly all kinds and varieties of products. Ultimately, coal consists of but five great elements, but the permutations and combinations possible from the various proportions and arrangement of these elements in various substances, is innumerable.

Coal gas efficiency has two phases:

1st. How much is accounted for of the original weight?

2nd. In what form is it accounted for?

To simplify the matter as to an understanding of the subject concretely, Mr. Vivian B. Lewes in his recent book on coal carbonization said:

"In considering the ultimate effect of pushing temperatures to the highest possible extent, it is well to consider the amount and value of the coke and gas that could possibly be obtained from an ordinary coal were we to carbonize it in an inverted vertical retort with the coal fed in by a ram at the bottom, so that the gas and vapors had to traverse a column of 10 ft. of coke at 1,000° C., contact would decompose all the gaseous and volatile compounds into hydrogen and carbon monoxide, and we should obtain:

	Feet	Per cent.
Hydrogen .....	22,400	77.87
Co.....	6,366	22.13

or a yield per pound of coal of  $\frac{28,766}{2,240} = 12.8$  ft. of gas per pound.

This shows the futility of operating to secure the maximum yield and using it as the criterion of progress and efficiency.

It is self-evident, that the process is the most efficient, which, while giving the required quality of gas, gives the most gas with the production of the most valuable coke and other by-products.

is my purpose, therefore, to demonstrate the fact that the oven, or carbonization in bulk, gives high efficiency, and is so because the methods of carbonization in use, are which are based on the soundest principles.

#### RECOGNIZED PRINCIPLES OF COAL GAS MANUFACTURE.

With the introduction of the vertical retort, it was demonstrated to the gas industry what had been known for a long time to the coke industry—that a filled vessel evenly heated would give increased gas yield, increased gas quality, better and more coke, higher ammonia, better and more tar. In short, there seemed to be an improvement at every point of manufacture. The reason was not far to seek. Carbonization proceeded from the hot wall surface forming a zone of reaction the products of which condensed on the side in contact with the relatively cold coal, forming an almost impenetrable film, which gradually redistilled, forcing the gas to flow counter current to the heat flow. While the temperature outside of the chamber or oven wall is high, the contact of the carbonizing material with the wall served to pull down the inside temperature, the result being, that while the temperature of the wall was sufficient to develop the vapors of hydrocarbons of high molecular complexity, into fixed and hydrocarbons of low complexity, nevertheless, the temperature was not of sufficient intensity to disassociate them in their elements.

This is in marked contrast to the stop end horizontal retort, only one-third full, exposing the gas as evolved from the bottom to a passage along an overheated top surface having nothing to do, or no work to do, and, therefore, almost as hot inside as outside.

With the appreciation of this principle, the through retort makers were able to avail themselves of the value of the demonstration by increasing very markedly the height of the retorts in their retorts, thus decreasing not only the volume of gas in contact with the hot top, but also the time of contact. The increase in gas yield by this method, with no loss



in quality, only served to confirm the general principle, that gas made with full chambers in which the gas was not exposed to overheated surfaces, was made on proper and proved principles.

As far back as 1902, Hilgenstock showed that the carbonization of coal in a coke oven proceeded in planes parallel to the oven walls in which there was formed a film of tarry condensate, on one side of which the gas was evolved by redistillation, and distillation passing through the already coked coal and up the oven wall, while on the other side, the fresh coal was acting as a condenser for the freshly formed tarry vapors.

In 1902, Hilgenstock read before the German Gas Association a paper showing the results of tests made on coke ovens as to the conditions obtaining during carbonization. In this he said: (See *Journal of Gas Lighting*, Vol. 80, Page 1,145).

"On considering the coking seam somewhat more closely, it will be seen that it forms the clearly recognizable dividing diaphragm of thick tar between the raw and almost unaltered coal and the solid coke, from which, however, the gas has not yet been completely dispelled."

Last year before the Institute, O. B. Evans demonstrated that while a certain portion of the gas in intermittent vertical retorts, passed through this film and through the coal mass to the top and out, the majority passed from the outside of the film through the coke and up the oven wall.

This deduction is well expressed by Alfred E. Forstall in a recent paper before the Society of Chemical Industry:

"Mr. Evans, reasoning from the pressure conditions, existing in the interior of an intermittently charged vertical retort, came to the conclusion that during the early part of the charge, when the layer of coke formed around the perimeter of the retort was compact and offered no ready means of passage to the gas, most of the gas produced was obliged to force its way through the pasty layer of coal in the initial stage of carbonization, and pass up through the uncarbonized coal, but

that as the outer layer of coke contracted and cracked under further heating most of the gas formed in the latter portions of the charge passed up through this coke. He also concluded that of the gas made during the first 6 hours which amounted to 70 per cent. of the total made, 45 per cent. passed up inside of the pasty layer through the core and 55 per cent. through the hot coke next to the retort walls, and that the gas evolved at low temperatures escapes through the core while that evolved at high temperatures escapes along the wall."

I believe this is further substantiated by the fact that the system of vertical operation of which Mr. Evans speaks, has the further advantage of a "superheater" at the retort top. This unfilled space at the top of the retort is operated at about 1,350° F. It is exceedingly unlikely that the gas coming into the retort top from the outside of the charge is affected in this space, having previously been heated beyond this temperature; on the other hand, it is more than likely that the low temperature gas passing from the core of the charge does improve by being brought to a temperature of 1,350° F. in the retort top.

Hilgenstock, in his paper, said that the principle of gas making in retorts in which the gas must come in contact with highly heated surfaces, was wrong, and prophesied that coal gas engineers in the future would avail themselves of the more correct principle of oven carbonization, in which the gas was required to pass along a wall, but which wall was kept below the destruction temperature by being in contact with material which was constantly conducting the heat from it.

Such has been the case in the introduction of the vertical retort in the application of coke oven principles to large coal gas undertakings. When the vertical retort (intermittent) was introduced, the claim was made that the low naphthalene and high tar and ammonia yields were due to the fact that the gas was formed and passed through the core of the charge. This idea has been thoroughly refuted and I believe that this contention no longer exists.

No claim has ever been made that in the coke or gas oven, other than a small portion of low temperature product gas passes through the coal mass. An investigation of this matter was conducted by the H. Koppers Company and the results given out in a paper read by Peters in 1908, from which I quote the following abstracts:

"The heated wall surface must be covered with coal so that the heat transmitted into the mass, may be used for the distillation. It must purposely be avoided to overheat the gas on its way to the offtake.

"Coke and gas oven chambers are constructed in this manner: The conditions existing in a gas retort are not found in such chamber ovens, for instead of the present primary gases becoming overheated and broken down on the hot surface, these primary products are condensed and redistilled by the advancing heat, giving larger coke yields and an increased ammonia yield, producing a light fluid tar with the elimination of graphite and stopped standpipes. If the walls of a coke oven are heated uniformly and the coal is charged into the oven in such a way that the entire heating wall is covered, then there is no possibility of the products of distillation being broken down. If the walls are not uniformly heated or the coal does not cover the entire heated wall, it is found that the gas becomes inferior, while both tar and ammonia yields fall off.

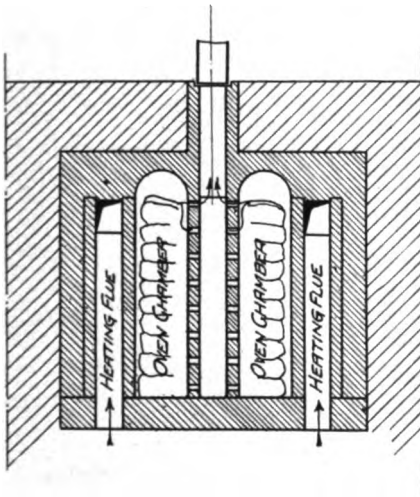
"As long as the oven chamber still contains coal in the center of the charge, the temperature of the inside of the oven chamber is comparatively low and of such a degree, that the produced gases do not undergo decomposition."

These facts proved by Koppers tests were also substantiated by the results of experiments made by another large coking company.

"This company built ovens as shown in Fig. 1.

"Between each two chambers there was a wall containing openings which ended in vertical channels in this wall. It was assumed that the gases produced in the two adjacent oven

chambers would pass through the coal mass toward this unheated dividing wall and through the openings into the vertical wall channels. The ovens were heated by flues on the opposite side of the wall through which the gas was supposed to pass. The result was a colossal failure. The gas instead of passing through the coal mass, passed up the heated oven walls, down the other side and out. The coal mass guarded



*JOURNAL FÜR GASBELEUCHTUNG UND WASSERVERSORGUNG, LI JAHRE.  
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Fig. 1.—Oven heated on side opposite from gas exit.

by the diaphragm of condensed tar was impregnable. The only result was a very largely increased coking time."

#### KOPPERS GAS OVEN.

The gas oven as designed for American coal is a narrow chamber 37 ft. long, 17 in. average width and 8 ft., 6 in. high. It is heated by thirty vertical flues connecting into a common horizontal flue extending along the top of the oven, but below the surface of the coal mass.

The gas to each oven is set by means of two metal cocks, which regulate the quantity of gas consumed in the vertical

flues, one cock being on the coke side and one on the pusher side.

The hot secondary air is admitted from the regenerators through openings adjacent to the gas openings, the two meeting and the combustion occurring through this vertical flue. In the top of each vertical flue is an adjustable sliding brick. This may be moved so that by changing draft

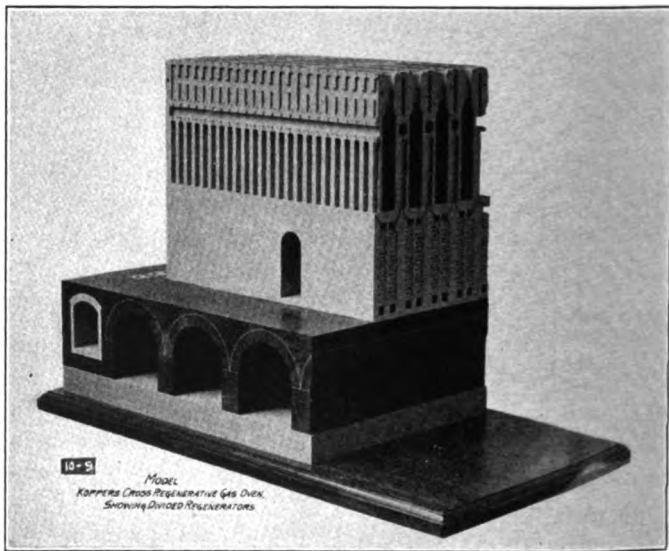


Fig. 2.—Model of Koppers' cross regenerative gas oven.

conditions, the length of flame can be regulated, and perfect combustion obtained in each flue. It is therefore patent that the oven walls are capable of the most even and exact temperature regulation.

Should the general heats be too high, the amount of gas may be cut down to suit the conditions on main oven gas valve. Thus the gas oven presents an ideal gas making chamber, filled to such a point that the gas passing from the car-

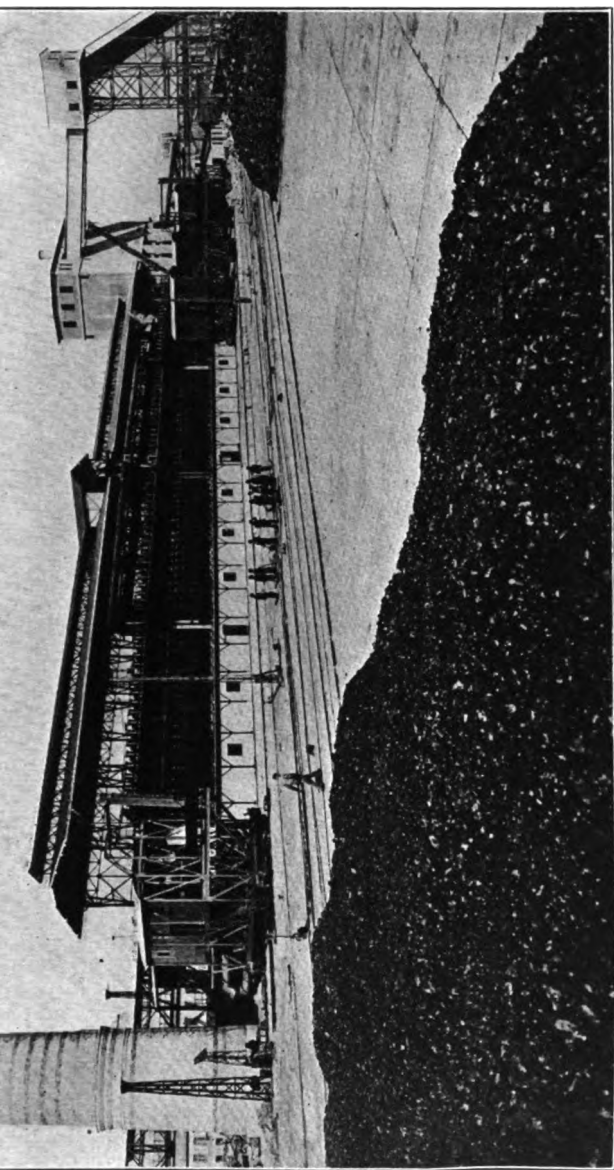


Fig. 3.—Koppers' Gas ovens at Budapest.

bonizing mass, is not further heated since the horizontal flue is below the top of the coal mass.

The fact that the producer gas is of uniform quality, free from dust, and of a composition unalterable by heat, makes the maintenance of uniform conditions exceedingly simple; *in fact*

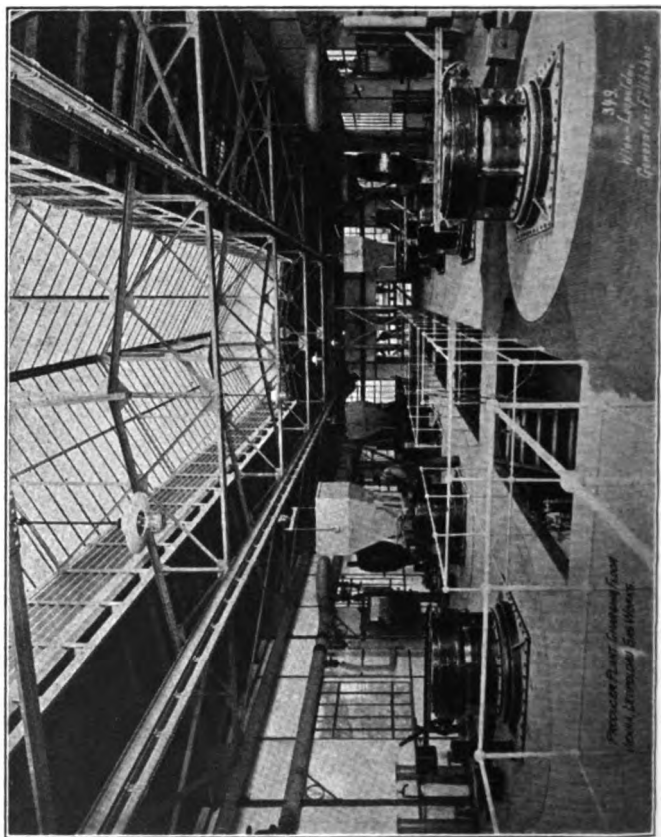


Fig. 4. — Producer plant at Leopoldau.

*the regulation of heats on a gas oven is even less of an operation than on a coke oven.*

Not only must such a gas chamber be properly heated in order to obtain efficient results, but it must be tight and remain

tight. Such is the construction of the walls with tongues and groove-brick, and with such careful allowances for expansion, that the walls may be said to be perfectly tight. There is every reason to believe that there is no leakage whatever in a Koppers Gas Oven using high volatile coal.

Gas ovens built in Germany, Austria and England have not been built of silica brick, but of high grade clay brick. Gas ovens to be built in America will be built of silica brick, as a wide acquaintance with the use of this material in coke ovens in this country, makes it possible to say that no matter what success has been achieved abroad on this type of plant, the silica built ovens will be more satisfactory.

One of the chief advantages of the gas oven lies in the large amount of material handled at one time. A gas oven conceived for American gas coals would have a capacity of 11.3 tons. The handling of this amount of material at one time has many advantages. These advantages obtain in low labor and uniform conditions of carbonization, coupled with low investment cost and low repairs.

There is also in connection with the excellent conditions of carbonization, a great flexibility of gas production.

What is the benefit as compared to any type or retort as to uniform conditions of operation? Consider a charge of 11.3 tons or 22,600 pounds of coal placed in either intermittent vertical retorts holding 1,500 lbs. per charge or through horizontal retorts holding about 900 lbs. In the first instance, this amount of coal will occupy 15 retorts; in the second, 25 retorts. It is as impossible to vary the charge in all these retorts to suit the exact conditions as it is to preserve exactly the proper condition. The result is that some charges are too small for the heat, while others are too great. In one case the coal is overcoked; in the other, it comes out undercarbonized. The best that can be achieved is to work toward an average. One can see at once the advantage which the bulk carbonization has in having the regulation so fine, and the time of carbonization so long, that the slight possible variation in the condition of the individual oven is negligible.



## FURTHER ADVANTAGES OF THE GAS OVEN.

*Low Labor Cost.*

There are two reasons for low labor cost in gas ovens. 1st, by handling the coal in large quantities, it is possible to obtain low labor by adopting mechanical means for movement; 2nd, on account of long carbonizing periods, it is possible to concentrate the work and thus do away with all oven labor during a large portion of the twenty-four hours. This is taken advantage of in the Continental plants where only fire brick material is available. This adapts itself well to a 24-hour coking period, under which condition all the charging and pushing is done in the daylight hours, and no night shift is required other than a watchman and the operator in the producer house.

To illustrate this low labor feature, the following is a list of men necessary to operate a battery of seventy-eight 10-ton ovens, making approximately 9,000,000 ft. of gas per day.

## LABOR AT BUDAPEST—78 OVENS.

*Ovens.*

- 1 Pusher operator
- 1 Man for leveler machine
- 2 Helpers
- 1 Man for coke quenching station
- 2 Helpers
- 1 Larry operator
- 2 Laborers for ovens
- 2 Men for collecting main
- 2 Gas and air regulators

---

14

*Coal Transport from Dumper.*

- 1 Mechanic
- 1 Laborer

---

2

*Coke Transport from Chamber.*

- 1 Mechanic
- 1 Laborer

---

2

*Producer Service.*

- 3 Operators for steam engines, resp. motors
  - 2 Foremen
  - 4 Laborers
  - 9
- 

*Supervision.*

- 2 Foremen

*Cleaning.*

- 1 Bricklayer
- 

30 Total number of men required for 24 hours.

This shows a total of 30 men, or a total amount of coal handled per man per day of 26.0 tons.

If we suppose that these men receive \$2.50 per day, under American conditions, the total manufacturing labor would

amount to  $\frac{30 \times 2.50}{9,000} = 0.83\text{¢}$  per thousand feet which you

will grant is exceedingly low.

In this country, it is not calculated to get as low labor as this.

American gas coal can be more efficiently handled on narrower ovens and on shorter coking time. As soon as the coking time is lowered below 24 hours, it becomes necessary to increase the number of shifts. The extra labor necessary is more than over-balanced by the extra output of gas per oven and the consequential curtailment of investment costs.

Labor on gas ovens will vary somewhat with the size of the plant, inasmuch as part of the number of men necessary to operate the plant is somewhat of a constant.

To illustrate the difference in the composition of coal as used on the Austrian gas oven plants abroad, and standard gas coal as used in America, the following analyses will be of interest :

	Westmoreland American coal export seam	Dombrauer Austrian coal
Volatile matter.....	33.50	31.90
Fixed carbon.....	60.50	60.50
Ash.....	6.00	8.60

The products of coal, laboratory distillation, are as follows:

	2,000 pound basis	
	Westmoreland Pounds	Dombrauer Pounds
Tar.....	68.40	55.00
Combined water .....	91.60	108.80
Carbonic acid.....	11.36	39.60
Hydrogen sulphide.....	8.50	3.60
Ammonia.....	7.50	5.94
Gas by weight .....	323.30	299.60
Coke .....	1,487.34	1,487.46
Total .....	2,000.00	2,000.00

Ultimate analysis shows that the oxygen in Dombrauer coal is 8.5, while that of Westmoreland coal is 7.05.

All of the gas coals used abroad are not high oxygen coals, and while the American coals lend themselves better to lower carbonizing time than the Austrian coal mentioned, the contributing factor is the ability to use silica brick walls. The extra conductivity of this material allows the carbonization to be much hastened, while preserving a high factor of safety. Low coking time by increasing the output per oven decreases the investment cost, which, together with normal general operating efficiencies, more than offsets the low labor by having but one shift. In plants of very small capacity, this would not hold true, however, for obvious reasons.

#### COKE QUALITY.

In his latest book on "The Carbonization of Coal", Vivian B. Lewes says:

"In America, the by-product oven is a success because long ago they had the sense to abolish bituminous coal as a domestic fuel, and it is high priced anthracite and not cheap bituminous coal that the coke has to compete with, and as metallurgical coke is a fuel that answers perfectly in the closed anthracite stoves, it follows naturally that the domestic market is open to it. In England, however, with our open grate fires, often with hardly enough draft to burn bituminous coal and needing an easily ignited and free burning fuel, such coke would have no

chance of success, and this so alters the whole position, that one has to admit that carbonization in bulk can succeed only in those districts where metallurgical coke is a necessity."

Coke quality is, therefore, a matter of prime importance in coal gas manufacture in America. Coke must be sold in competition with anthracite coal, and must have qualities resembling those of anthracite coal.

Coke quality is a function of two controlling features. 1st, Coal quality and characteristics; 2nd, Conditions of coking. Metallurgical coke is coke having the necessary characteristics which enable it to be used in metallurgical processes, such as for pig iron production in blast furnaces. It must be hard, must have crushing resistance, a certain degree of porosity, low sulphur and low phosphorous content. It must have a certain molecular condition of carbon which gives it a resistance to consumption in the presence of hot carbonic acid in the gases.

It is customary among blast furnace operators to conduct certain tests to determine the character of coke. (For testing methods, see *Bureau of Mines*, Bulletin 8, Technical Paper 50.)

These are:

- 1st—Shatter test.
- 2nd—Porosity test.
- 3rd—Specific gravity.
- 4th—Crushing strength.
- 5th—Solubility in  $\text{CO}_2$  at  $1,000^\circ \text{C}$ . ( $1,832^\circ \text{F}$ .).

The Gas Manager in the past has been primarily a coal gas manufacturer rather than a coke manufacturer, and has been slow to an appreciation of the situation.

Most of the gas house coke in this country has been "stop end retort coke".

Though the gas manufacturer found difficulty in disposing of the surplus coke from his plants, he had been rather too contented to take things as they were instead of examining into conditions affecting his business.

Coke sales are an important factor of coal gas manufacture, and the engineer must wake up to the conditions. The com-

petition is with anthracite, and the result of trying to use in this competition soft, friable, dirty, "unburned-off" coke, rapidly deteriorating into breeze, is determined at the outset. Either such coke will not sell, or if it does, the competition price is ruinous.

The answer is to make a coke that will compete with anthracite on equal terms, or nearly so.

In connection with the preparation of this paper, the idea was conceived of having various plants using different processes of coal gas manufacture send to a prominent steel plant, samples of their coke for testing purposes, and it was my purpose to show what the variation in coke quality is.

After some hesitation, I have decided not to submit these test results, but to recommend to the Institute that a committee undertake this work. I might say in passing, that these results were exceedingly interesting; for example, the variation in specific gravity among the samples submitted was as much as 52 per cent. and the variation in percentage of cells, 25 per cent. The variation in "shatter test" was equally as great.

I have not given the results of these tests because I could not be sure that the samples submitted were truly representative, but such work could be carried out by an Institute Committee to excellent purpose.

The gas oven as conceived for operation in America on gas coals with the purpose of securing all the gas of high quality, will *not make* true metallurgical coke but will make coke entirely suitable for domestic purposes and which will compete favorably with anthracite. It will have strength, and may be handled with a minimum of breeze. From the very nature of its method of manufacture, it will be harder, stand more handling and bring higher prices than coke made by many other coal gas methods.

The importance of coke sales becomes impressive when we consider that in the average coal gas plant, practically 100 lbs. of coke must be disposed of for every 1,000 cu. ft. of gas manufactured. It is also significant that a variation in the

ice of 50 cents per ton of coke, will affect the cost of as approximately 2.5 cents per thousand cubic feet. Quality of coke made in ovens is such as to give a great deal over other coal gas processes, so far as extent of yield and selling price is concerned.

### QUALITY OF TAR.

made on a gas oven is of high grade and commands high prices. The amount of creosote oil is exceedingly high and pitch content low. The amount of free carbon will not exceed 2 per cent. The following is a comparison of the tar obtained from the distillation of coal on two gas making

analyses were made by the United Gas Improvement Company Standard Tar Distillation Method in the same laboratory by the same chemist with the same apparatus.

"A"			"B"		
Received from company. Made on through retorts.			Sample received from Vienna. Made on Koppers Gas Ovens.		
Carbon.....	22.20 %		Free carbon.....	2.65 %	
Hydrogen.....	50.67 %		Coke .....	16.1 %	
Specific gravity .....	1.249		Specific gravity .....	1.107	
Weight per gallon.....	10.37 lbs.		Weight per gallon.....	9.19 lbs.	
Distillation	Per cent. by volume	Specific gravity	Per cent. by volume	Specific gravity	
to 300°	00.0	—	2.9	0.8977	
" 350°	00.0	—	4.1	0.9620	
" 400°	4.0	1.0515	11.2	1.0024	
" 450°	6.0	1.0774	10.5	1.0332	
" 500°	7.0	1.0864	7.8	1.0662	
" 550°	2.3	1.1061	7.2	1.0774	
" 600°	8.0	1.1244	8.3	1.0951	
" 650°	6.2	1.1371	7.3	1.1213	
" 700°	4.0	1.1537	8.0	1.1414	
" 750°	5.5	1.1687	13.0	1.2260	
Over 750°	9.6	1.2160	7.2	—	
	52.6		87.5		

essentially everything from 400° to 650° would be recovered as creosote oil—below that, light oil—above, pitch.

Under this division, we would have in

"A"	Per cent.	"B" Per cent.
Light oil .....	4.0 by volume	18.2 by volume
Creosote oil.....	29.5 " "	41.1 " "
Pitch.....	67.5 by weight	40.7 by weight

Since pitch is the ingredient least valuable, it follows that the oven tar is of higher intrinsic value.

The fact that the free carbon is also so much lower, would give it a better value from a distilling cost standpoint.

So far as quantity of the tar is concerned, the gas oven will give as much as any other system operating on the same coal and making the same quality of gas.

#### *Ammonia.*

Coal contains as one of its elemental components, nitrogen. During the process of distillation, the nitrogen is given off in five ways, the amount being a function of two variables. (1) The condition of the nitrogen in the coal; (2) The heat to which the coal and its products is subjected.

In each coal, there is a definite temperature up to which the ammonia increases in amount as the temperature is raised and above which there is a deterioration.

Professor Oscar Simmersbach has recently made important experiments along these lines, the results of which may be found in an article in "*Stahl und Eisen*" Nos. 28 and 29, 1914. In the appendix will be found an abstract translation of this paper, which I feel will prove of general interest.

I beg to call your attention to Table I, Sec. A, B and C and Table II.

Table I shows that the maximum ammonia is formed on Upper Silesian coal containing 1.396 per cent. of nitrogen, at a temperature of 900° C. or 1,652° F. This amount formed, namely, 24.12 per cent., corresponds to a yield of about 8.2 lbs. of ammonia per net ton of coal. 1.396 per cent. nitrogen corresponds to 27.92 lbs. of nitrogen per net ton. It is interesting to note at this temperature of maximum formation what the distribution from a ton of coal, is, in the products:

Ammonia $\text{NH}_3$	Cyanogen $\text{CN}$	In tar
8.2 lbs.	0.61 lb.	1.16 lbs.
(6.73 nitrogen)	(0.33 nitrogen)	
As free N in gas		In coke
3.39 lbs.		
Equivalent to 46 cu. ft.		16.3 lbs.
On a make of 10,000 ft.		
per ton—this becomes 0.46		
per cent. in volume.		

Of interest, in connection with this, we find in Table II, the production of gas as compared with the yield of ammonia. This shows that when obtaining a gas of about 600 B. t. u.'s and a high calorific multiple, that the maximum of ammonia was formed.

The temperatures at which he finds the maximum yield of ammonia are those at which the best gas results are obtained. It is generally regarded that the best gas making temperature lies between 800 and 900° C. It is also true that the maximum yield of ammonia takes place between these points. It would seem a logical deduction, therefore, that that process which gives the best yield of ammonia, conducts the distillation in a manner to give the best gas results.

*In examining the efficiency of any process from a gas making standpoint, it is well to know what ammonia is recovered.*

The gas oven when operated to give high yields of 600 B. t. u. gas, will give as ammonia practically 24 per cent. of the nitrogen in American gas coal.

#### *Advantages of Koppers' Gas Ovens.*

Summarizing, the Koppers' gas oven has the following advantages:

1st. The oven is heated with clean, cold gas from an extraneous source.

2nd. This gas is made in a producer plant so arranged as to give high efficiency and to use the coke breeze made in the ovens and during coke handling.

3rd. The quantity of this material necessary together with the good coke used amounts to only 11 per cent. to 12 per cent. of the weight of coal carbonized.



4th. The producer gas is capable of exact regulation for each oven.

5th. The oven is heated by thirty vertical flues, the heat in each one being capable of adjustment.

6th. Ovens are charged to a point higher than heat is applied, thus protecting the gas from over-heating on its passage above the coal.

7th. All heated walls are in contact with conducting material on which and through which the heat is being used, thus reducing the temperature below the point of injury to the gas.

8th. By use of regenerators, heating both secondary air and producer gas, the temperature of the outgoing stack gases is reduced to below 500° F., thus giving a high thermal efficiency of carbonization.

9th. By handling coal and coke in large masses, labor is decreased and mechanical operation used to great advantage.

10th. Gives a hard coke which can compete with anthracite coal at similar prices. Such coke contains nearly 10 per cent. more fixed carbon than anthracite sold for domestic purposes and will stand handling with little deterioration.

11th. Cost of the complete plant including producers is as low as any other form of efficient coal gas apparatus.

12th. Being constructed of silica material, the life of the plant is very great and repairs reduced to a minimum.

13th. The advantage of complete heat control in the ovens makes it possible to raise and lower the coking time quickly and efficiently, thus permitting the amount of coal carbonized and the consequent gas output to be varied with the seasons and as demands are made for gas.

14th. Carbonization in gas ovens gives maximum yields of high quality gas together with high ammonia yield, high tar yield of maximum value and an excellent coke.

While over 2,300 ovens of this design have been contracted for and built in America to be used as coke ovens and operated by coke oven methods, no plants have yet been built using the

central producer plant and taking all the gas from the coal for distribution.

It is necessary, therefore, to turn to the European plants for an examination into results.

The following plants have been built and contracted for throughout the world:

	Ovens	
Vienna .....	152	
Berlin .....	40	These have a capacity of nearly 50,000,000 cu. ft. per day.
Budapest .....	78	
Kiel .....	23	
Koenigsburg .....	35	
Birmingham, England .....	66	
Tokio .....	60	
Stockholm .....	45	
Total.....	499	

The following tables show the results on gas production and producer operation at Vienna and Budapest:

#### RESULTS OF TESTS ON SOME EUROPEAN PLANTS.

##### *Vienna, Leopoldau.*

Test made by Gas Works Authorities May 19 to May 25, 1912.

1. Number of ovens in operation—36.
2. Number of chambers pushed per day—36.
3. Coking period—24 hours.
4. Kind of coal used—
 

Pol. and Mahr—Ostrauer District....	78.24 per cent.
Karwin and Dombrauer .....	17.96 per cent.
District unspecified .....	3.80 per cent.
	<hr/>
	100.00 per cent.
5. Coal characteristics—
 

Moisture .....	2.70 per cent.
Fixed carbon and vol. ....	87.55 per cent.
Ash .....	9.75 per cent.
	<hr/>
	100.00 per cent.
6. Heating value of coal—ash deducted per lb.—12,950 B. t. u. according to Berthelot-Mohler.
7. Total coal carbonized in 6 days—2,624.4 net tons.
8. Total coal carbonized—with the correction made for ash above 8 per cent.—guarantee basis—2,579 tons.

9. Average coal charged per chamber—guarantee coal basis—11.94 tons.
  10. Total gas metered at 70.5° F. 198.3 mm.—794,470 M<sup>3</sup>; holder pressure 747.98 mm. at.—28,056,550 cu. ft.
  11. Gas produced at 60 deg. and 30 in.—27,111,660 cu. ft.
  12. Average gas produced per day at 60 deg. 30 in.—4,518,610 cu. ft.
  13. Gas yield, corrected, on guarantee coal—per ton, 10,513 cu. ft.; per lb., 5.26 cu. ft.
  14. Gross B. t. u. value at 60 deg. 30 in.—618.
  15. B. t. u. per lb. coal—  
Cal. multiple (13)  $\times$  (14) = 525  $\times$  618 = 3,245.
  16. Number of producers in operation—4.
  17. Weight of coke and breeze in producers, including 13 per cent. water and 12.7 per cent. ash—344.7 tons.
  18. Amount charged dry—305 tons.
  19. Amount of coke charged, calculated to an ash of 11.4 per cent. (as per test coal)—287 tons.
  20. Dry coke containing 11.4 per cent. ash, per ton of test coal used—11.1 per cent.
  21. Assuming calorific value of coke as 12,500 B. t. u.'s per lb. dry B. t. u.'s required in producer per lb. of coal—1,388.
  22. *Analysis of Producer Gas*—
 

CO <sub>2</sub> .....	2.60 per cent.
O <sub>2</sub> .....	0.25 per cent.
CO .....	29.50 per cent.
H .....	9.98 per cent.
CH <sub>4</sub> .....	0.42 per cent.
N .....	57.25 per cent.
	100.00 per cent.
- 134 B. t. u. per cu. ft.
23. Quantity of water evaporated during test—825,000 lbs.
  24. Water evaporated per lb. of coke as charged—1.2 lbs.
  25. Net thermal efficiency of producer plant and ovens, assuming 726 B. t. u.'s necessary to carbonize a lb. of coal— $\frac{726}{1,388}$  no allowance for steam produced over that used—52.3 per cent.

*Kiel, Germany.*

January 6 to 12 inclusive, 1914.

**Plant of 23 Koppers horizontal cross regenerative central producer plant operated gas ovens.**

1. Number of ovens in operation—23.
2. Number of ovens charged per day—23.
3. Coking period—24 hours.
4. Kind of coal used—English, "New Levenson."
5. Characteristics of coal—
 

Moisture .....	2.3 per cent.
Vol. matter and carbon.....	86.4 per cent.
Ash .....	11.3 per cent.
6. Average heating value of coal as received—12,518 B.t.u.'s
7. Total coal carbonized in 6 day test, calculated to 8 per cent. ash basis—1,128 net tons.
8. Average coal charged per oven, guarantee coal basis—8.17 tons.
9. Total gas metered—12,852,540 cu. ft.; read at average temperature 67.8, pressure 770 mm. at 194 holder, 964 mm.
10. Gas production corrected to 60 deg. + 760 mm. (30 in.)—12,712,560 cu. ft.
11. Average corrected gas produced per day—2,118,760 cu. ft.
12. Gas yield, corrected, guarantee coal—11,270 cu. ft. per net ton, 5.635 yield per lb.
13. Gross B.t.u. value at 60 deg.—760 mm. (30 in.)—574. Junkers calorimeter.
14. B.t.u. per lb. coal— $(12) \times (13) = 3,234$  B.t.u.'s.
15. Guarantee coke (11.4 per cent. ash) used in producers—139.1 net tons.
16. Coke (guarantee 11.4 per cent. ash) used per ton of guaranteed coal (8 per cent. ash)—246 lbs. = 12.3 per cent.

*Budapest, Austria.*

Feb. 21 to 27, 1914.

TABLE I.—RESULTS OF GUARANTEE TEST CARRIED OUT WITH BATTERY OF 39 KOPPERS CHAMBER GAS OVENS.

	Unit	Prelim. test	1st day	2nd day	3rd day	4th day	5th day	Total	Average
Number of ovens in operation	—	39	39	39	39	39	39	234	39
Number of ovens charged	—	39	39	39	39	39	39	234	39
Average time of carbonisation per charge	Hours	24	24	24	24	24	24	144	24
Average time taken for discharging and recharging a chamber	{ Minutes Seconds	7 4	8 34	6 51	6 38	6 43	7 41	26 11	7 15
Coal gasified (Dombrauer-Revier)	Net tons	426.77	420.60	429.48	428.68	424.75	431.96	2,570.68	428.45
Composition of coal:									
Water	Per cent.	4.12	3.26	3.20	3.71	3.10	3.43	—	3.470
Ash	Per cent.	7.77	9.69	8.80	8.73	9.03	9.57	—	8.933
Pure coal	Per cent.	88.11	87.05	88.00	87.56	87.87	87.00	—	87.597
Total	Per cent.	100.00	100.00	100.00	100.00	100.00	100.00	—	100.000
Coal gasified per chamber	Net tons	10.942	11.016	11.000	10.976	10.892	11.076	65.902	10.983
Total coal gasified without moisture and ash	Net tons	376.03	373.97	377.54	374.83	373.26	375.81	2,351.44	375.24
Total coal gasified with 8 per cent. ash and 2½ per cent. moisture	Net tons	420.14	417.84	421.83	418.80	417.05	419.90	2,515.56	419.26
Gas production at 60° F. and 30"	Cubic feet	4,770.639	4,712.583	4,799.420	4,745.213	4,755.978	4,826.400	28,610.133	4,768.355
Saturated gas output per chamber at 60° F. and 30"	Cubic feet	122.328	120.845	122.928	121.657	121.939	123.740	733.437	122.243
Output of gas per net ton of raw coal at 60° F. and 30"	Cubic feet	11.180	10.970	11.175	11.084	11.195	11.171	66.775	11.129
Saturated gas output per ton of coal with 8 per cent. ash and 2½ per cent. moisture	Cubic feet	—	—	—	—	—	—	—	11.373
Gross calorific value of the gas of 60° F. and 30"	Cubic feet	556	559	569	567	564	569	3,384	564
Calorific multiple—Yield × B. t. u.	B. t. u.	—	—	—	—	—	—	—	3,207

	Unit	Prelim. test	1st day	2nd day	3rd day	4th day	5th day	Total	Average
Specific gravity of the gas . . . . .	—	—	—	—	0.448	—	—	—	0.448
Nitrogen content of the gas by direct determination . . . . .	Per cent.	5.80	4.98	4.77	4.92	5.37	5.68	—	5.25
Output of coke (with moisture) in per cent. of coal . . . . .	Per cent.	—	—	—	—	—	—	—	75.1
Grading of coke:									
Above 2" . . . . .	Per cent.	—	—	—	—	—	—	—	38.82
Nut coke, 1" to 2" . . . . .	Per cent.	—	—	—	—	—	—	—	43.81
Small coke, ½" to 1" . . . . .	Per cent.	—	—	—	—	—	—	—	7.58
Dust, to ½" . . . . .	Per cent.	—	—	—	—	—	—	—	9.79
Total . . . . .	—	—	—	—	—	—	—	—	100.00
Composition of the separate classes of coke:									
Kind of coke . . . . .	—	—	Above 2"	—	1" to 2"	2½" to 1"	Dust to ½"	Averages	
Moisture . . . . .	—	—	2 14	—	7.32	11.02	18.03	6.63	
Ash . . . . .	—	—	11.22	—	11.44	14.89	17.99	12.24	
Combustible . . . . .	—	—	86.64	—	81.24	74.09	63.98	81.13	
Total . . . . .	—	—	100.00	—	100.00	100.00	100.00	100.00	
Brown coal used as fuel in the producers, calorific value of brown coal, 7,560 B. t. u. per lb. . . . .	Net tons	82.957	75.441	77.349	79.474	80.784	84.715	480.720	80.120
Fuel required per net ton raw coal . . . . .	Pounds	398.8	351.2	360.6	375.2	380.4	392.2	2,248.2	374.7
B. t. u. required to carbonize 1 lb. coal . . . . .	—	—	—	—	—	—	—	—	1,416
Equivalent in coke, coke being 12,500 B. t. u. per lb. . . . .	—	—	—	—	—	—	—	—	11.3%

## TO SUMMARIZE THE TESTS.

With coal inferior to American coals in quality—producing a lower standard of gas calorific value—the results showed as follows:

	Gas yield per pound	Calorific value	Calorific Multiple	Underfiring per cent.
Vienna.....	5.26	618	3,245	11.1
Kiel .....	5.635	574	3,234	12.3
Budapest.....	5.64	564	3,207	11.3

None of these ovens are built of silica material and would be at a disadvantage compared to silica ovens with American coals.

The plant nearest to this country has been built at Birmingham, England. The plant as originally built consisted of 12 gas ovens operated by a Mond producer gas plant. The operation of this small battery was so successful that an addition of 54 ovens was decided upon. An innovation is planned on these batteries, using the Mond producer to furnish the producer gas operating on the recovery principle. In this it is planned to secure approximately 70 lbs. of sulphate per ton of producer coal. This new plant is about ready for operation and should prove of great interest, inasmuch as a successful operation will mean that the cost of the producer gas is practically nothing.

In a paper read before the Institution of Gas Engineers in June, 1913, Mr. W. Cheney gives the following results of a 7 day test on the 12 oven battery:

The following figures were obtained from a mixture of 50 per cent. South Yorkshire coal and 50 per cent. of Derbyshire coal unstamped.

1. Duration of test—7 days.
2. Number of ovens charged—84.
3. Gas made, corrected for temp. and bar. (CO<sub>2</sub> not removed)—8,219,000 cu. ft.
4. Coal carbonized (raw)—728 net tons.
5. Analysis of coal—
 

Water .....	4.0 per cent.
Ash .....	4.5 per cent.

6. Gas made per ton of coal, corrected for temp. and bar.—11,300 cu. ft. (5.65 per lb.).
7. Illuminating power, No. 1 burner ( $\text{CO}_2$  not extracted)—14.05 candles.
8. Illuminating power, No. 2 burner ( $\text{CO}_2$  not extracted)—17.00 candles.
9. Calorific value—net 500 B. t. u. per cu. ft.
10. Calorific multiple—2,825 net.
11. Specific gravity of gas—0.437.

*Analysis of Gas—*

Carbonic acid .....	2.1 per cent.
Hydrocarbons .....	2.9 per cent.
Oxygen .....	0.7 per cent.
Carbonic oxide .....	7.8 per cent.
Hydrogen .....	50.0 per cent.
$\text{CH}_4$ .....	30.0 per cent.
Nitrogen .....	6.5 per cent.

B. t. u.'s gross, 560.

B. t. u.'s per lb., 3,164.

Sulphur in gas other than  $\text{H}_2\text{S}$ , 30.7 grains per 100 cu. ft.

Cyanides as  $\text{Na}_2\text{Fe}(\text{CN})_6$ , 3.34 lbs. per 10,000 cu. ft.

While the figures on foreign plants are of academic interest, it is not until figures are given on American coals under American conditions, that the matter of gas ovens becomes of concrete value. For this reason, I am sure that the results of the operation of Koppers' ovens will prove of interest.

It is to be deplored that the results of tests conducted were not made in connection with a central producer plant, but so far as the production of coal gas is concerned, this makes no difference, excepting for the fact that coke ovens for the production of coke, and gas ovens for the production of gas are not similar in their proportions, and such tests when made for gas on coke ovens are not the whole story. The ovens used in the test below have the following dimensions:

Length between doors.....	40 ft. 4 in.
Height of coal .....	10 ft. $1\frac{1}{4}$ in.
Average width .....	19 in.



The dimensions which we would regard as suitable for a gas oven on American coal would be:

Length .....	37 ft.
Height .....	8 ft. 10 in.
Width .....	17 in.

The fact that the ovens used were higher and wider militated against results. This plant was the only one so situated as to enable it to be run as a gas oven, and we felt fortunate to have that. The results, therefore, are very conservative and serve as a good indication of what might be expected under better conditions.

ACCOUNT OF TEST BY MARYLAND STEEL CO. AT SPARROWS  
POINT, MD., ON KOPPERS' OVENS CONDUCTED BY ED-  
WIN BARNHART ASSISTED BY MR. DUVAL,  
COKE PLANT CHEMIST.

A few years ago, the Maryland Steel Company, in order to convince themselves of the correctness of the claims made for the Koppers' cross-regenerative coke oven, erected a small battery of six 15-ton ovens in close proximity to their Otto-Hoffman batteries which were at that time in operation. These six ovens were connected with the mains of the old batteries and so arranged that the gas could be taken away in the same main and through the same by-product plant.

About October 15, 1913, it was decided to abandon their old batteries and to shut down the experimental Koppers six oven plant also. It seemed an excellent opportunity to find out what such ovens would do when operated as gas ovens, recovering all the gas, by-products and coke. An arrangement, therefore, was made with the Maryland Steel Company to continue the ovens in operation and make such changes as would allow them to conduct a test along these lines.

The plant was equipped with a drum station meter, but it was necessary to change the piping so that all the gas made would first pass through this meter and be recorded; a portion of this gas was then returned to the battery to effect the car-

bonization. Connections were made at the outlet of the final cooler so that the gas might be sampled continuously and the pipe led to the regular photometer room, where 24-hour averaging tanks were available, as well as a 5 ft. gas holder for continuous reading through which the gas could be burned continuously and be read at regular intervals.

There were many difficulties to be overcome and endured during the test. As soon as the old plant was shut down, the large 30-in foul gas mains extending for nearly  $\frac{1}{8}$  of a mile to the six oven plant, contracted, loosening all the joints. These joints had to be gone over carefully and calked.

The exhauster system as well as the condensers and tar extractors were intended for millions of feet of gas where we had hundreds, and it was exceedingly difficult to maintain any even pull on the mains. This was rendered more difficult by the fact that the ovens held 15 tons of coal each and the tremendous variation in the amount of gas made, when a fresh oven was put on the line, made it an impossible task to have good regulation. In addition to this, the two takeoff mains on the battery were but 12 in. in diameter, so that, not being intended for any such amounts of gas as we were making, a heavy back pressure was at times put on the ovens.

Another difficulty lay in the fact that in order to charge 15 tons of coal at one charge, it was necessary to use the two old Otto-Hoffman larry cars which had to be brought up an incline to the Koppers battery. This made it necessary to consume forty minutes in charging an oven, which in ordinary practice should have consumed but 6 to 8 minutes on the outside. During 20 minutes of this period, large amounts of rich gas were poured out into the atmosphere, for which it was impossible to make an allowance on gas, candle-power, heat units or tar and ammonia. Despite these troubles, it was decided to go ahead with the test, appreciating that the difficulties only added factors of safety and conservatism to anything we would find, and that if we got fair results, we would secure better results in actual operation.

## DISPOSITION OF PLANT.

Plant consists of six cross-regenerative ovens of the Koppers general type, in which no preheating of the fuel gas is secured, but have a low radiation factor and a high thermal efficiency. The ovens were equipped with two 12-in. take off mains connected into a 30-in foul main extending for  $\frac{1}{8}$  of a mile to the exhauster room.

Exhauster having a capacity of 350,000 ft. per hour; Huntoon governor actuated by connection to inlet to exhauster. (It was impractical to connect to ovens.) Electric signals provided to indicate condition of pressure at ovens. Gas then passed through P & A tar extractors, a cooler, scrubber and final cooler, and then passed through the station meter. From the station meter the gas divided, part going to the exhauster and part to the relief holder. This relief holder was connected to the fuel main and also served as an accumulator for the exhauster.

## METHOD OF CARRYING OUT TEST.

It was desired to make the following tests: Yield, of gas, average candle-power, average calorific value, ammonia, tar and coke.

*Yield.*

Station meter was tested and found defective. Upon opening the case, a large hole was found in the drum. The drum was repaired and the meter put into general first class condition by the Maryland Meter Company. The meter was then tested by the Maryland Meter Company in conjunction with the Baltimore Gas Company and the Maryland Steel Company and was found correct.

Coal weights were taken in two ways. It was impossible to weigh each charge, but the cubic contents of each oven was definitely known, and twice a day the weight of a cubic foot of coal was accurately determined. The bins were emptied before and after the test, and an accurate weight of the coal placed in the bin determined. That the total weight checked

within 1 per cent. of the coal placed in the bins, attested the accuracy of this method.

#### *Candle-Power.*

Candle-power was determined by examining the gas on a standard bar photometer built by the United Gas Improvement Company. The burner used was a Sugg "D", American Meter Company burner. During the test, readings were also taken on a new Sugg "D", on a Metropolitan Burner No. 2, on an open flame Bray No. 7 Universal Slit.

The standard was a Harcourt Standard pentane lamp certified and calibrated by the U. S. Bureau of Standards. During the test, readings were also taken against a Hefner Standard and an Elliott 5 C. P. Standard.

The photometer was calibrated by the use of a certified cubic foot bottle. Gas was conducted from the outlet of the final cooler maintained at 70° F.

The lead pipe was covered and protected from temperature variations by the use of a small live steam pipe included in the covering.

In the Photometer Room, a 5 cu. ft. gas holder was connected, automatically kept full so that the gas passed in and out constantly maintaining an hourly average of the gas made.

Trained photometer readers took hourly observations for candle-power, calorific value and specific gravity.

#### *Calorific Value.*

Calorific value was determined by the use of an American Meter Company Junkers Calorimeter. All thermometers were calibrated by the U. S. Bureau of Standards. Meter calibrated against standard cubic foot bottle. Methods of testing were those prescribed by the A. G. I. Calorimeter Committee and all advices considered, including the use of an overhead water tank to secure water room temperature.

#### *Specific Gravity.*

Specific gravity determined by Standard Schilling specific gravity apparatus.

*Gas Analyses.*

Gas analyses were made twice daily by the chemist of the Maryland Steel Company. Apparatus used was the Barnhart modification of the Hempel apparatus. All nitrogen determinations were checked.

*Tar and Ammonia.*

Tar and ammonia were measured in calibrated tanks, careful measurements and analyses of the contents being made from time to time during the test.

*Coke.*

Coke was ascertained by weighing all cars. Moisture tests were taken during test.

*Coal Carbonized.*

Coal used was of two kinds:

- (1) West Virginia coal from Underwood, W. Va.
- (2) Pennsylvania coal from Pittsburgh district.

The average analyses of these coals were as follows:

	West Virginia	Pittsburgh
Volatile matter.....	37.34	35.19
Fixed carbon.....	55.79	56.76
Ash.....	6.69	8.05
Sulphur.....	1.44	1.24
Phosphorous.....	0.013	0.014

*Result of Test.*

The gas coal was put into the ovens on November 9, 1913. Inasmuch as no data could be secured with reference to gas yields until the meter was ready, all data previous to that time, November 30th, in so far as gas was concerned, was disregarded.

At the 1914 meeting of the Illinois Gas Association certain figures were given out as the tar and ammonia yields from the two kinds of gas coal on this test. These figures were deduced from the data received from the Steel Company making the test. After talking the matter over with them, we have decided that there is a reasonable doubt as to the accuracy of the figures over short periods of time on large capacity tanks.

We have, therefore, concluded to give the tar and ammonia figures as determined over a longer period.

These show as follows:

	Gallons
Tar on hand November 9th .....	646,454
“ “ “ December 25th .....	648,523
Gain in stock .....	2,069
Tar sold during period.....	62,921
Total tar made .....	64,990
Gross coal carbonized.....	Tons 4,545
Tar produced per net ton .....	Gallons 14.3

In the same manner the ammonia yield showed as follows:

	Pounds
On hand, November 9th .....	24,993
On hand, December 25th .....	29,612
Gain in stock .....	4,729
Sent to ammonia still during period .....	26,838
Ammonia made .....	31,567
Coal, carbonized.....	Tons 4,545

Ammonia ( $\text{NH}_3$ ) per net ton

$$\frac{31,567}{4,545} = 6.94 \text{ lbs.}$$

equivalent to 27.76 pounds of sulphate.

In connection with the quality of the gas made during different periods, the following samples were taken from one oven over the entire coking period.

	Sample from 11:30 a. m. to 4:30 p. m. Per cent.	Sample from 4:30 p. m. to 9:30 p. m. Per cent.	Sample from 9:30 p. m. to 2:30 a. m. Per cent.	Sample from 2:30 a. m. to 7:30 a. m. Per cent.
Carbon dioxide .....	1.60	1.40	1.00	0.90
Heavy hydrocarbon ..	5.50	4.20	3.10	0.60
Oxygen .....	0.50	0.40	0.40	0.40
Carbon monoxide ....	7.80	7.50	6.90	6.90
Hydrogen .....	45.80	48.40	53.40	73.20
Menthane .....	38.00	36.10	32.40	15.90
Nitrogen .....	0.80	2.00	2.80	2.10
B. t. u. calculated....	676.0	636.0	590.0	434.0

PITTSBURGH GAS COAL TEST ON THE KOPPERS 6 OVEN PLANT OF THE MARYLAND STEEL COMPANY  
DECEMBER 8 TO 20, 1913 INCLUSIVE.

Dec. 1913	No. ovens chgd.	Aver. coking time	Coal charged lbs.	Coal charged per oven	Cor. gas made cu. ft.	Cor. yield per lb.	Cal. val. B. t. u.	Cal. mul- ti- ple	Candle power new Sugg. D.	Candle feet	Coal thru 1/8" mesh per cent.	Wt. cu. ft. dry coal
11	7	20	220,400	31,490	1,179,140	5.35	614	—	15.52	—	33.50	51.36
12	7	20	219,700	31,380	1,184,180	5.39	608	—	15.34	—	47.10	51.19
13	7	20	223,300	31,900	1,165,620	5.22	612	—	16.90	—	42.20	52.05
14	7	20	219,600	31,370	1,210,000	5.51	612	—	17.29	—	47.90	51.18
15	7	20	228,400	32,530	1,178,540	5.16	600	—	16.01	—	46.50	53.20
16	7	20	222,100	31,730	1,150,480	5.18	598	—	15.23	—	49.30	51.75
17	7	20	226,000	31,280	1,213,600	5.37	607	—	15.19	—	53.50	52.50
18	7	20	223,300	31,900	1,221,450	5.47	596	—	15.21	—	43.20	52.00
19	7	20	218,400	31,200	1,179,300	5.40	608	—	15.17	—	49.70	50.83
20	7	20	210,400	30,060	1,153,000	5.48	593	—	15.39	—	38.80	49.33
Aver.	7	20	221,160	31,580	1,183,530	5.35	605	3,237	15.72	84.10	43.40	51.34

TEST ON WEST VIRGINIA COAL ON THE KOPPERS 6 OVEN PLANT OF MARYLAND STEEL COMPANY  
DECEMBER 2 TO 6, 1913 INCLUSIVE.

2	7	20 1/4	215,000	30,730	1,090,551	5.07	616	3,113	17.15	—	43.50	50.14
3	6	20 1/4	187,200	31,200	1,119,450	5.98	631	3,773	17.60	—	41.00	50.91
4	7	20 1/4	212,300	30,300	1,159,160	5.46	621	3,391	15.82	—	41.30	49.48
5	7	20 1/4	221,600	31,667	1,132,380	5.11	619	3,163	16.02	—	43.4	51.65
6	7	20	213,200	30,460	1,151,280	5.40	634	3,424	15.49	—	48.4	49.66
Aver.	6.8	20 1/4	209,880	30,860	1,130,560	5.39	624	3,363	16.42	88.50	43.5	50.37

<sup>1</sup> Only 6 charges of coal counted on 24 hours.

**GAS ANALYSIS.**  
**WEST VIRGINIA COAL.**

Date 1913 Dec.	CO <sub>2</sub>	O <sub>2</sub>	III.	CO	CH <sub>4</sub>	H <sub>2</sub>	N <sub>2</sub>	B. t. u. per cu. ft.
2	1.85	1.25	4.35	7.10	32.30	47.50	5.65	616
3	1.70	1.35	4.65	7.10	33.20	46.60	5.40	631
4	1.40	0.60	4.65	7.05	31.65	50.45	4.20	621
5	1.70	0.80	4.50	7.15	30.75	49.40	5.70	619
6	1.50	0.65	4.10	6.75	32.25	48.25	6.50	634

**PITTSBURGH COAL.**

11	1.25	0.65	3.60	6.80	30.85	50.05	6.70	614
12	1.35	1.05	3.25	6.55	29.70	51.15	6.95	608
13	1.15	0.75	3.65	6.85	30.95	52.05	4.60	612
14	1.30	0.95	4.05	6.55	31.25	52.40	3.50	612
15	1.35	0.90	3.65	6.60	31.45	51.65	4.40	600
16	1.40	1.00	3.35	6.80	30.50	52.35	4.60	598
17	1.00	0.90	3.65	6.75	30.95	51.25	5.50	607
18	1.30	1.05	3.95	6.95	31.70	50.30	4.75	596
19	1.45	0.90	3.60	6.90	30.90	52.40	3.85	608
20	1.40	1.05	3.10	7.35	31.10	51.75	4.75	593

**GAS ANALYSIS**

MADE BY BALTIMORE GAS COMPANY AFTER PUMPING FROM SPARROWS POINT. GAS ANALYSIS ON ELLIOTT APPARATUS.  
CALORIMETER—JUNKERS.

Information supplied by courtesy of Mr. George Beadenkopf, Engineer,  
Consolidated Gas, Electric Light and Power Co. of Baltimore, Md.

**AVERAGE DAILY SAMPLES.**

Date 1913 Dec.	CO <sub>2</sub>	O <sub>2</sub>	III.	CO	CH <sub>4</sub>	H <sub>2</sub>	N <sub>2</sub>	B. t. u. per cu. ft.
<b>WEST VIRGINIA COAL.</b>								
2	1.7	0.4	4.7	7.0	33.7	50.9	1.6	621
3	1.5	0.7	5.4	6.7	35.1	49.3	1.3	650
4	1.3	0.7	4.7	6.6	31.9	53.6	1.2	619
5	1.5	0.7	4.5	6.6	30.8	55.6	0.3	629
6	1.2	0.9	4.3	6.5	32.8	52.4	1.9	631
<b>PITTSBURGH COAL.</b>								
11	1.8	0.6	3.2	6.4	31.7	54.4	1.9	631
12	1.4	0.4	4.2	6.3	33.0	51.6	3.1	616
13	1.4	0.2	3.6	6.2	30.9	55.8	1.9	598
14	1.2	0.8	3.7	6.2	31.4	54.5	2.2	615
15	1.2	0.4	3.8	6.0	32.3	54.3	2.0	601
16	1.6	0.5	3.6	6.0	31.4	54.0	2.3	615
17	1.6	0.5	3.7	6.5	32.0	53.8	1.9	608
18	1.6	0.5	4.0	6.1	30.8	56.3	0.7	607
19	1.3	0.7	3.4	6.4	32.8	53.0	2.4	593
20	1.3	0.4	3.3	6.5	31.3	52.4	4.8	586



## THE BY-PRODUCT COKE OVEN.

It seems to me, while I have already a perhaps too lengthy paper, that the subject of "Carbonization in Bulk" would not be complete without some reference to the by-product coke oven as a source of gas supply, and giving you a short summary of the essential features of that process.

The production of by-product coke is constantly increasing, and while in general it may be said that the gas resulting from the making of coke in this way is being used in iron and steel industries, still there is an increasing amount being sold to gas companies for distribution.

Government reports give the following as the amount of coke made in this country since 1893 with certain years omitted:

## PRODUCTION OF COKE.

Year	By-product coke	Beehive coke	Totals
1893	12,850	9,464,730	9,477,580
1901	1,179,900	20,615,983	21,795,883
1907	5,607,899	35,171,665	40,779,564
1908	4,201,226	21,832,292	26,033,518
1909	6,254,644	33,060,421	39,315,065
1910	7,138,734	34,570,076	41,708,810
1911	7,847,845	22,703,644	35,551,489
1912	11,048,489	32,868,345	43,916,834
1913	12,714,700	34,385,300	47,100,000 <sup>1</sup>

<sup>1</sup> Approximate.

It will thus be seen that while the total amount of coke made has increased from 40,779,000 in 1907 to 47,100,000 in 1913—or about 15 per cent.—The amount of by-product coke has increased from 5,608,000 to 12,714,700 tons, an increase of 126 per cent.

Some idea of the amount of gas which would be available, were the whole amount of beehive coke to be made in modern by-product coke ovens, may be secured by assuming the production of 8,500 feet of surplus gas per net ton of coke. This would amount to 292,000,000,000 cu. ft. per year or 800,000,000 cu. ft. per day.

There is no question but what every steel plant in the United

States is practically convinced, that the operation of a by-product coke plant means a large economy in their operation and that the future will see large developments in this line. On account of this feature, the gas man will be called upon to take notice of the matter. While such gas can be used to great advantage in steel plants, it rarely happens that the value of the gas in the plant can be reckoned at much over 8 cents. For this reason, gas companies in the vicinity of such plants will be expected to take advantage of the condition, as the sale at higher prices will prove of mutual advantage both to the steel company and the gas company.

With the increasing cost of anthracite coal and the probability of the competition of coke of such a quality in this market, it is also probable that the future will see large plants erected for making domestic fuel in the great centers of population, and some disposal must be made of the gas. For these reasons, the subject will not be without interest.

By-product coke of excellent quality can be made from coals of varying characteristics and in the plants now in operation; all classes of Eastern coals are used from the lean coals of the Pocahontas district to the rich coals of the Pittsburgh area. Operators for the most part use a mixture of the two, operating on from 80 to 20 per cent. of the high volatile, but recently one of the important plants of the Steel Corporation was placed on straight high volatile coal.

Since the object of coke plants is to make coke with certain characteristics, it is customary in the average by-product plant to make this feature paramount. The amount and quality of the resulting gas and the amount of by-products are thus of secondary importance. I do not mean that there is no appreciation of the value of these products and that their saving is not watched with the most minute attention, but coke capacity and coke quality come first.

For this reason, the coking time is lowered as far as possible in order to get as much coke from the plant investment as possible, despite the fact that the yield of tar and ammonia

fall off per ton, tremendously. Some times we feel that this is carried to excess, and it would pay to construct more ovens, run them on higher coking time and increase the return per ton of coal.

The gas is recovered in two systems: 1st—*Without separation*; 2nd—*With Separation*.

#### *With Separation.*

Since the quality of the gas varies with the period of the carbonization, it follows that by separating the gas from the early hours of the charge, from that coming off later, a gas of high calorific value may be obtained. For this reason it is necessary to have two mains on the battery and transfer the oven takeoff from one to the other, as is required to furnish enough of the low calorific gas to operate the battery. This involves extra investment in extra mains and in separate by-product recovery apparatus, and is not done unless the gas is needed for some purpose as for urban use where a high calorific intensity makes the investment worth while.

#### *Without Separation.*

When no high calorific value is required as in steel plant use, it is not customary to separate the gas. All the gas is taken off in a homogeneously lower calorific condition, treated for by-product recovery together, and what is needed is returned to the battery.

To come down to practical operation, which I believe will prove of the greatest interest, let us consider the operation of a plant on a mixture of 65 per cent. Pittsburgh and 35 per cent. Pocahontas, with and without gas separation:

#### *Analysis of Coals.*

	Pittsburgh	Pocahontas
Volatile matter .....	34.06	18.26
Fixed carbon.....	59.92	76.00
Ash.....	6.02	5.74

The  $\frac{65}{35}$  mixture would, therefore, show on analysis:

Volatile matter.....	28.53
Fixed carbon.....	65.55
Ash .....	5.92

If we consider a  $1\frac{3}{4}$  ton oven operating on 18 hours coking time, we would expect to get from each ton of this mixture:

B. t. u. 's.	B. t. u. 's.
2,000 x 3,000 .....	6,000,000
Tar .....	7 gallons
	Pounds
Sulphate of ammonia .....	22
1,480 pounds total coke .....	1,380 coke
	100 breeze

There would be used in the carbonization per net ton 2,400,000 B. t. u.'s, leaving 3,600,000 in surplus gas.

If we took the gas off without gas separation and secured 10,800 cu. ft. per ton, we would have an average calorific value of 555 B. t. u.'s. Of this we would use  $\frac{2,400,000}{555} = 4,320$  ft.

on the ovens per ton—leaving as surplus gas 6,480 ft. of 555 B. t. u. gas.

Should we use gas separation, we would secure 5,700 ft. of 632 B. t. u. gas as surplus using 5,100 ft. of 471 B. t. u. gas under the ovens.

Should it be desirable to remove the benzol from the gas, we would expect to recover from all the gas 2.2 gallons per net ton, under which conditions we would have as products the following:

10,800 ft. of total gas of 555 B. t. u.'s = 6,000,000.

2.2 gallons of benzol having a heating value of  $2.2 \times (0.8846 \times 8.3) \times 18,477 = 297,920$  B. t. u.'s.

We would, therefore, have remaining after the benzol was deducted:

$6,000,000 - 297,920 = 5,702,080$  B. t. u.

The volume of the benzol removed would be

Net per G. cu. ft. per lb.

$2.2 \times 7.34 \times 4.845 = 78.23$  cu. ft.

The value of the gas remaining would, therefore, be

$\frac{5,702,080}{10,800 - 78} = 532$  B. t. u.'s per cu. ft.

Carbonization would. therefore, require

$$\frac{2,400,000}{532} = 4,510 \text{ cu. ft.}$$

Leaving as surplus

$$10,722 - 4,510 = 6,212 \text{ cu. ft. of } 532 \text{ B. t. u. gas.}$$

#### BENZOL RECOVERY WITH GAS SEPARATION.

If we assume that 2.2 gallons of benzol are recovered per net ton, of which 1.5 gallons are recovered from the rich gas and 0.7 gallon from the lean gas, we find as follows:

Lean gas — 5,100 cu. ft. of 471 B. t. u.

$$2,400,000 \text{ B. t. u.'s}$$

$$0.7 \text{ gallon equals } 04,794 \text{ B. t. u.'s}$$

$$2,400,000 - 94,794 = 2,305,208$$

$$\frac{2,305,208}{5,100} = 425 \text{ B. t. u.'s.}$$

We are, however, short 94,754 B. t. u.'s of having enough heat.

Assuming 600 B. t. u.'s. as the value of the debenzolized rich gas, we find that we must add

$$\frac{94,754}{600} \text{ approx.} = 160 \text{ cu. ft.}$$

So that we would have as lean gas:—

$$\left. \begin{array}{l} 5,100 \text{ ft. of } 452 \\ 160 \text{ ft. of } 600 \end{array} \right\} \text{ or } 5,260 \text{ cu. ft. of } 456 \text{ B.t.u.'s.}$$

This leaves as rich gas

$$10,800 - 4,260 \text{ cu. ft.} = 5,540 \text{ cu. ft.}$$

Since the rich gas contained 3,600,000 B. t. u.'s. and we have removed  $1.5 \times 7.3 \times 18,447$  B. t. u.'s as benzol =  
201,995 B. t. u.'s.

Leaving in 5,544 cu. ft.—( $1.5 \times 7.3 \times 4.885$ ) 5.487 cu. ft.

$$\frac{3,600,000 - 201,995}{5.487} = 619 \text{ B. t. u.'s}$$

*To Summarise.*

On a Koppers  $13\frac{1}{4}$  ton coke oven, operating on a mixture

of 65 per cent. Pittsburgh and 35 per cent. Pocahontas on 18 hours' coking time, we would expect to get from each net ton:

1,360 lbs. of furnace, foundry and domestic coke.

100 lbs. of breeze.

7 gals. of tar.

22 lbs. of ammonium sulphate.

Without gas separation = 6,480 cu. ft. of 555 B. t. u. gas

With gas separation = 5,700 " " " 632 B. t. u. gas

Without gas separation but with a benzol plant — 2.2 gallons benzol 6,200 cu. ft. of 532 B. t. u. gas

With gas separation and a benzol plant — 2.2 gallons benzol 5,450 cu. ft. of 619 B. t. u. gas.

It will, therefore, be clear to you that there is a marked difference in the amount of coke and gas received net on a coke oven plant and on a gas oven.

On a gas oven on straight American gas coal, we would expect to get:

1,140 lbs. coke and 11,000 cu. ft. of gas or

1,000 ft. of gas for each 103 lbs. of coke.

On the coke oven, we would get with gas separation and using such a coal mixture = 5,700 ft. of gas and 1,360 lbs. of coke or 238 lbs. coke per M. ft. of gas.

The Koppers Company has built and put into operation since the last meeting of the Institute, 3 plants:

Inland Steel Company, Indiana Harbor, Ind.—66 13¼-ton ovens.

Republic Iron & Steel Company, Youngstown, Ohio—68 13¼-ton ovens.

Maryland Steel Company, Sparrows Point, Md.—120 13¼-ton ovens.

In the first two plants, the gas is all being used in the steel processes. In the third plant, only half of which has been put into operation, the surplus gas is being delivered to the Baltimore Gas Company. This plant is of further interest to gas engineers inasmuch as the benzol is being removed from the lean gas and put into the rich gas to increase its candle-power.

It is too soon to attempt to give results on this plant other than to say that it is working in a most satisfactory manner.

#### COMBINATION GAS AND COKE PLANTS.

A type of plant which has been built by the H. Koppers Company in Germany, and which will prove of interest, is the combination plant. This is so arranged that the plant may be run with producer gas from the central plant, or by coke oven gas. Any oven may be changed over from one to the other at a moment's notice. Under such a condition, the amount of coke made is a constant, while the amount of coal gas made, has a possible variation of almost 100 per cent. This type of plant has the flexibility usually associated with a water gas plant and should make a wide appeal under certain conditions.

Such is the status of carbonization in bulk. It is my hope before many meetings of this Institute have taken place, that America may see a gas oven plant of this type with producer operated from a central plant, carbonizing American coals.

In closing, I wish to express my appreciation of the assistance given by Mr. Joseph Becker, Superintendent of Operation, H. Koppers Company, in the preparation of this paper.

#### APPENDIX.

##### FORMATION AND DECOMPOSITION OF AMMONIA DURING COAL DISTILLATION.

(Reviewed from *Stahl und Eisen* Nos. 28 and 29, 1914.)

Prof. Oskar Simmersbach recently made some very interesting and instructive laboratory experiments to study the phenomena of formation of ammonia and cyanogen during the distillation of coal and of decomposition of ammonia in the presence of incandescent coke.

To carry out the experiments relative to the distribution of nitrogen during coal carbonization, special elaborate apparatus was necessary for the simultaneous, quantitative determination of coke, tar, ammonia and cyanogen. Distillation of the

coal samples was performed in a glazed porcelain tube by means of an electric furnace. The temperature could be regulated and was recorded by means of a registering pyrometer. The apparatus required for making the required measurements and determinations as well as the test methods employed are fully described and illustrated in *Stahl und Eisen* Nos. 28 and 29, 1914.

The results of Simmersbach's tests relative to the distribution of nitrogen are shown in Table I.

TABLE I.—DISTRIBUTION OF NITROGEN.

Nitrogen content of drip coal free of ash = 100 per cent.

(A) Upper Silesia coal of 6.63 per cent. ash and 1.396 per cent. nitrogen (referred to dry coal free of ash) = 100 per cent.

Temperature		As ammonia.	As cyanogen.	In tar.	As free nitro-	In coke.
°C.	°F.	Per cent.	Per cent.	Per cent.	gen in gas.	Per cent.
(a) Size of grain 2 to 2½ mm.						
600	1,112	7.81	0.25	2.12	18.13	71.69
700	1,292	18.13	0.66	3.65	12.13	65.43
800	1,472	21.28	0.87	3.47	10.73	63.65
850	1,562	23.68	1.11	3.72	10.37	61.12
900	1,652	24.12	1.19	4.15	12.14	58.40
1,000	1,832	23.15	1.23	4.11	21.53	49.98
1,100	2,012	23.09	1.31	3.70	30.51	41.39
1,200	2,192	22.84	1.42	4.21	45.10	26.43

(b) Size of grain 6 to 10 mm.

850	1,562	23.75	1.11	3.52	15.67	55.95
900	1,652	24.19	1.23	3.47	16.81	54.30
1,000	1,832	22.69	1.26	3.39	23.79	48.87

(B) Westphalia coal of 5.77 per cent. ash and 1.391 per cent. nitrogen (referred to dry coal free of ash) = 100 per cent.

Size of grain 2 to 2½ mm.

800	1,472	19.46	0.76	1.92	5.88	71.98
850	1,562	22.14	1.10	1.77	4.93	70.06
900	1,652	19.94	1.11	1.61	9.99	67.35
1,000	1,832	19.61	1.25	1.67	21.54	55.73

(C) Lower Silesia coal of 6.21 per cent. ash and 0.965 per cent. nitrogen (referred to coal free of ash) = 100 per cent.

Size of grain 2 to 2½ mm.

850	1,562	24.74	1.49	2.63	5.56	66.58
900	1,652	26.95	1.61	2.73	5.04	63.67
1,000	1,832	25.49	1.87	2.60	15.71	54.33



The maximum yield of ammonia of Upper Silesia coal occurred at  $900^{\circ}\text{C}$ . ( $1,652^{\circ}\text{F}$ .). The size of grain of the coal had no influence either on the temperature at which the maximum yield occurred or upon the yield itself. At a still higher temperature, the coarse grain seems to hasten the decomposition of ammonia. At  $1,000^{\circ}\text{C}$ . ( $1,832^{\circ}\text{F}$ .) a greater reduction in ammonia yield takes place.

The cyanogen content increases with increasing temperature and its maximum is apparently not reached at  $1,200^{\circ}\text{C}$ . ( $2,192^{\circ}\text{F}$ .). Coarse grain coal shows a small increase in cyanogen constant over fine grain coal at temperatures of  $900^{\circ}$  and  $1,000^{\circ}\text{C}$ ., whereas no difference could be observed at  $850^{\circ}\text{C}$ . ( $1,562^{\circ}\text{F}$ .).

While the figures pertaining to nitrogen in tar vary somewhat on account of variation in decomposition of tar as well as owing to the difficulty of complete tar recovery, the maximum amount is unquestionably near 4 per cent. of the total nitrogen with fine grain coal, while the tar from coarse grain coal contains only 3.5 per cent. of the total nitrogen. Fine coal retains more nitrogen in the coke with less nitrogen entering the gas in elementary form up to  $900^{\circ}\text{C}$ . than coarse grain coal; at  $1,000^{\circ}\text{C}$ . these values approach each other more.

The nitrogen contents of the cokes from coarse grain coal referred to dry coke free of ash are considerably lower than those from fine coal.

As shown in Table II, the gas yield by volume from coarse coal is somewhat smaller than that of fine coal, while no material difference exists in quality even at  $900^{\circ}$  and  $1,000^{\circ}\text{C}$ . At lower temperature, however, ( $850^{\circ}\text{C}$ .) the gas from coarse coal seems to contain more methane and heavy hydrocarbons.

With Westphalia coal, the maximum ammonia yield occurs at  $850^{\circ}\text{C}$ . ( $1,562^{\circ}\text{F}$ .) *i. e.*, at a lower temperature than with Upper Silesia coal. Here too, the cyanogen content increases with increasing temperature. The gas yield is much higher

TABLE II.—COMPOSITION OF GAS EXCLUDING CO<sub>2</sub>, H<sub>2</sub>S, HCN & NH<sub>3</sub>.

## (A) Upper Silesia Coal:

Average samples from beginning of distillation to point when temperatures given in first column are reached.

B. t. u's. per lb.	Temperature		Volume of dry gas reduced to 0° C. and 760 mm. merc. from 100 g. of dry coal free of ash.	Yield Liters	(a) Size of grain 2 to 2½ mm.								CH <sub>4</sub> Per cent.	H <sub>2</sub> Per cent.	H <sub>2</sub> Per cent.	B. t. u's.
	°C.	°F.			C <sub>2</sub> H <sub>6</sub> Per cent.	C <sub>2</sub> H <sub>4</sub> Per cent.	O <sub>2</sub> Per cent.	CO Per cent.								
1,154	600	1,112	7.03	1.10	2.4	4.5	0.9	4.2	78.4	1.4	8.2	962				
1,845	700	1,292	12.98	2.21	2.6	4.1	1.0	11.2	56.2	20.8	4.1	835				
2,204	800	1,472	18.45	3.14	1.8	3.0	1.1	7.4	43.4	38.0	5.3	702				
2,532	850	1,562	22.50	3.83	1.8	2.6	1.1	4.1	38.9	44.6	6.9	661				
2,525	900	1,652	24.28	4.14	1.0	2.2	0.6	5.3	35.2	50.2	5.5	610				
2,676	1,000	1,832	27.18	4.62	1.0	2.1	0.8	8.9	30.4	52.2	4.6	577				
2,525	1,100	2,012	28.24	4.80	0.7	1.7	1.0	9.1	26.2	54.7	6.6	526				
2,410	1,200	2,192	29.37	5.00	0.5	1.4	0.9	7.8	21.6	60.4	7.4	482				
(b) Size of grain 6 to 10 mm.																
850	1,562		21.56		1.3	3.4	0.1	7.1	44.8	39.3	4.0					
900	1,652		22.77		1.1	2.3	0.1	9.0	34.7	49.2	3.6					
1,000	1,832		25.42		0.8	2.0	0.1	8.1	30.0	53.4	5.6					
Size of grain 2 to 2½ mm.																
800	1,472		21.38		0.7	2.1	1.1	0.9	38.5	54.4	2.3					
850	2,562		25.58		0.5	1.6	0.55	0.7	35.0	61.35	2.3					
900	1,652		27.71		0.4	1.4	0.8	1.3	31.6	61.8	2.6					
1,000	1,832		29.73		0.3	1.3	0.65	3.65	23.4	65.5	5.2					
Size of grain 2 to 2½ mm.																
850	1,562		21.92		0.9	2.8	1.1	3.8	45.1	44.25	2.05					
900	1,652		25.01		0.6	2.55	1.0	3.8	40.9	48.15	3.0					
1,000	1,832		27.97		0.35	2.0	1.2	3.6	30.55	54.8	7.5					

## (B) Westphalia Coal:

## (C) Lower Silesia:

and there is considerable difference in chemical composition compared with Upper Silesia coal. Carbon monoxide and heavy hydrocarbons are much lower, while hydrogen is considerably higher.

Since the carbon deposited during decomposition of methane is hard and silvery, in counter-distinction to the carbon deposited by ethane, ethylene and acetylene which is soft and dull, the greater decomposition of methane with Westphalia coal explains the better appearance of Westphalia coke.

As shown by Mayer and Altmayer, the maximum yield from Saar coal occurs at  $800^{\circ}\text{C}$ . ( $1,472^{\circ}\text{F}$ .) or at still lower temperature than with Westphalia coal. These two investigators found moreover that cyanogen is formed only by the decomposition of ammonia when passing over incandescent coke.

In the experiments relative to the decomposition of ammonia, a continuous stream of pure, dry ammonia vapors was passed through a glazed porcelain tube partly filled with coke which could be heated to any desired temperature in an electric furnace. The gases of decomposition of ammonia were absorbed, the ammonia in dilute sulphuric acid and the cyanogen in potassium hydrate and ferro-sulphate solution. The coke used in these experiments had an apparent specific gravity of 0.93 and contained 8.32 per cent. of ash and 0.96 per cent. of sulphur. The coke was heated in the porcelain tube for about two hours at  $1,200^{\circ}\text{C}$ . to drive off all contained gases before the actual experiment was begun. A registering pyrometer showed the temperature in the electric furnace. As soon as a constant pressure was reached, the ammonia vapors were passed over the hot coke at atmospheric pressure for a certain period of time. Immediately after the test and after pressure, temperature, barometric and volumetric readings had been taken, the gases were analyzed according to Hempel.

The results of these tests are shown in the following table:

TABLE III.—DECOMPOSITION OF AMMONIA.

Temperature of coke layer of 10 cm. length—	Dura- tion of test Min	Dura- tion of contact with hot coke Sec.	Dry ammonia gas used Ccm.	Decom- posed into hydro- gen and nitrogen Ccm.	Trans- ferred into cyanogen Ccm.	Not de- composed and un- changed Ccm.	Not de- composed ammonia vapors in percent. of quantity used Per cent.	Decomposed ammonia in percent. of quantity used (including cyanogen) Per cent.
700	60	1.68	10,991	4,725	7	6,259	56.95	43.05
750	60	1.70	9,734	4,986	16	4,730	48.59	51.41
800	60	1.57	7,966	7,188	34	746	9.36	90.64
850	60	1.24	9,479	8,737	45	697	7.35	92.65
900	60	1.31	8,645	8,102	69	474	5.48	94.52
1000	60	0.84	9,534	9,433	30	71	0.75	99.25
1100	45	0.60	8,791	8,754	17	20	0.23	99.77
1200	30	0.70	6,210	6,199	799	4	0.06	99.94

TABLE III.—DECOMPOSITION OF AMMONIA.

Test No.	Temperature of coke layer of 10 cm. length		Duration of test Min.	Dura- tion of contact with hot coke Sec.	Dry ammonia used Ccm.	Decom- posed into hydrogen and nitrogen Ccm.	Trans- ferred into cyanogen Ccm.	Not de- composed	Not de- composed ammonia in percent. of total quantity Per cent.	Decom- posed ammonia (including cyanogen) Per cent.
	°C.	°F.								
1	700	1,292	27	0.66	14,889	3,541	9	11,339	76.16	23.84
2	700	1,292	60	1.68	10,991	4,725	7	6,259	56.95	43.05
3	700	1,292	60	3.44	4,691	2,915	5	1,771	37.76	62.25
4	700	1,272	60	3.75	5,118	1,918	2	3,198	62.48	37.52
5	750	1,382	60	1.05	17,598	6,412	14	11,172	63.48	36.52
6	750	1,382	60	1.70	9,734	4,988	16	4,730	48.59	51.41

The four experiments at 700° C. show distinctly the influence of time of contact between ammonia vapors and coke. The first test during which the time of contact was short shows considerably less ammonia decomposed than the second and third tests of  $2\frac{1}{2}$  times and 5 times the duration of contact.

Simultaneously less cyanogen was formed during tests No. 1 and No. 2 than during test No. 3; the formation of cyanogen thus apparently requires some time. Moreover, the gas must be dry as shown by test No. 4 when the drying of ammonia failed, since not even half of the quantity of cyanogen of test No. 3 was formed although the time of contact was about the same.

Test No. 4 shows plainly the great protective influence of water vapors although but little steam was present. There was even less ammonia decomposed than in test No. 2, although the latter shows double the gas velocity.

The two tests at 750° C. bear out the contention that the formation of cyanogen requires a certain time. During test No. 6 much less ammonia was used and decomposed than during Test No. 5 and yet more cyanogen was formed simply because of the longer time of contact. During Test No. 6 when the time of contact was half again as long as during test No. 5, over one third, 14.89 per cent. more ammonia was decomposed; this again proves the protective influence of higher gas velocity. On the strength of these results, Simmersbach reaches the following conclusions:

(1) The formation of ammonia occurs in the main at a temperature at which the coking of coal is already terminated.

(2) The formation of ammonia does not attain its maximum at one and the same temperature for all coals.

(3) This temperature depends upon the nature of the nitrogen compounds in the coal and varies from 800 to 900° C.

(4) Decomposition of ammonia which with concentrated ammonia occurs essentially at 750° C. and nearly completely at 800° C. is, owing to the attendant dilution, not in evidence

during the gasification of coal until  $900^{\circ}$  C. is reached, and it increases with increasing temperature.

(5) The formation of cyanogen increases with the quantity of ammonia and with increasing temperature although ammonia in concentrated form has an unfavorable influence upon the formation of cyanogen with increasing temperature above  $900^{\circ}$  C.

(6) The quantity of cyanogen formed during coal carbonization amounts to about 1.2 per cent. of the total nitrogen and to about 5 per cent. of the ammonia.

(7) Water vapors are detrimental to the formation of cyanogen, but favorable to the ammonia yield.

(8) Higher gas velocity checks the decomposition of ammonia and favors the formation of cyanogen.

(9) The size of grain of the coal has no influence either on the temperature of maximum ammonia or upon the yield itself.

(Mr. Ramsburg read an abstract of his paper and illustrated certain features by lantern slides.)

(Mr. H. L. Underhill (New York) in the Chair.)

THE ACTING CHAIRMAN: A vote of thanks is due to Mr. Ramsburg for his very interesting paper and slides.

(A motion to that effect was made, seconded and carried.)

THE CHAIRMAN: The discussion is open on this paper.

MR. A. B. WAY (Everett, Mass.): I want to ask if the saving in labor cost by doing all the charging and pushing during the daylight hours does not result in difficulties due to wide variations in the quantity and quality of the gas produced?

There is a gradual falling off in calorific value and candle-power of the gas during the coking period, starting almost at the beginning of the distillation. This is shown by the author on page 585, where analyses of the gas during successive 5-hour periods are given.

In other words, it is quite evident, that in that half of the 24 hours when no fresh coal is being charged, the gas

produced must steadily fall off from the average or standard, both in quantity and in quality.

In some of the analyses of gas given by the author, the extremely low nitrogen content together with the comparatively high oxygen appear to be irreconcilable. For instance, many of those at the bottom of page 587 are shown to contain much less nitrogen than is necessary to satisfy the amount of oxygen present if the latter be calculated to air.

One would not expect as much as 0.8 or 0.9 per cent. oxygen in the gas from the coal itself. Will the author state whether there is the possibility of an error in the oxygen determination?

A number of years ago, during some experimental work on purification, the question of high oxygen and low nitrogen engaged my attention. I had cautioned the chemists to work with the strictest care in making the analyses, yet results showed that with low oxygen, there would be high illuminants, and with high oxygen, low illuminants, and it seemed that the accuracy of our results was in inverse ratio to the amount of care exercised. The apparatus used was a Hempel with bromine water for the absorption of the illuminants and stick phosphorus for the oxygen.

After puzzling over the problem for some time, a simple experiment disclosed the difficulty. After absorbing the illuminants and oxygen from a sample of gas, I ran the latter back into the bromine pipette and removed the bromine fumes as usual in a caustic soda pipette, with the exception that I shook this caustic soda pipette more vigorously than usual. An increase in volume was the immediate result, and on running the gas again into the phosphorus pipette, oxygen was absorbed, equal in volume to that increase. The explanation was simple. In using the same caustic soda pipette several times for the absorption of bromine fumes, sodium hypobromide had been formed, and as this is not a very stable compound, but will give up oxygen on shaking, we had been

getting results which were farther from the truth, the more careful we were to shake well.

It seems to me, in view of this explanation of high oxygen in our results, that analyses made on the Barnhard apparatus might show even greater errors in the oxygen determination, because here the gas is bubbled through the solution which would have the effect of liberating more oxygen than vigorous shaking. Of course, an error in the oxygen on this account is accompanied by a corresponding error in the illuminants.

Let us take one of these analyses and see if this might not have been so: In the first analysis shown on page 587, if we calculate back from the B. t. u. per cubic foot, the calorific value of the illuminants, we find that it amounts to nearly 2,600 B. t. u. per cubic foot; rather a high figure I should say for the illuminants in coal gas. Now suppose oxygen equal to 1 per cent. of the gas had been taken up from the caustic soda pipette, this would mean that the percentage of illuminants shown are 1 per cent. too low. Calculating their calorific value on this basis, we have about 2,100 B. t. u. per cubic foot—quite a reasonable figure.

I do not pretend to say that there is an error here of exactly 1 per cent., but it seems quite probable that the percentage of oxygen is too high, and that of the illuminants, too low.

Since writing this, my memory has been jogged concerning the operation at Sparrow's Point plant of the Barnhardt apparatus for gas analysis. The same caustic soda pipette is used for taking out the carbonic acid as is used for taking out the bromine fumes, so if this pipette will give up oxygen, it gives it up on the determination of carbonic acid, which makes that result too low; it is only a little perhaps, but another slight increase upon the extraction of the illuminants, makes that one too low. We do not suppose that all the oxygen that is going to be given up would be given up by one application; so that when you come to the determination of oxygen, you have actually doubled the chance of error from this source, if there be such a chance of error. Furthermore, if you use that same



pipette for absorption of carbonic acid after the explosion, the percentage of carbonic acid thus determined, that is to say, the number of cubic centimeters measured will be low, and the calculation of the marsh gas and hydrogen and determination of the nitrogen by difference, will give you a slightly lower nitrogen. Because the relation is two to one and one-half, where you multiply your carbonic acid by two for your marsh gas, and then the hydrogen is two-thirds of the difference between the contraction and twice your marsh gas; so that an error may creep in there from that same source.

There is one more point on which I would like some information. If I have been rightly informed, the Koppers Company has committed itself to the use of coal much coarser than that first used in their ovens in this country. It must be admitted that the coke is benefited by fine crushing of the coal, especially in that pieces of slate are broken up also, and so have less tendency to cause cross fracture.

Mr. Ramsburg quotes Simmersbach in showing that as regards the ammonia yield, "The size of the grain of coal has no influence either on the temperature at which the maximum yield occurs or upon the yield itself. Though at a higher temperature, the coarser grain seems to hasten the decomposition." Also that "the gas yield by volume from coarse coal is somewhat smaller than that of fine coal while no material difference exists in quality even at 900 or 1,000° C."

As to the amount of gas that passes through the hot coke and along the walls, one might expect that the percentage would be greater with fine coal, because the semi-plastic diaphragm might, with coarse coal, contain holes through which gas may pass to the core, but apparently this should make no difference, for according to the author's conclusion No. 7 on page 572, "All heated walls are in contact with conducting material, on which and through which the heat is being used, thus reducing the temperature below the point of injury to the gas." Has Mr. Ramsburg's experience uniformly confirmed this conclusion, or has he encountered one or more exceptions to the rule?

MR. RAMSBURG: I should like to answer the questions as they are asked, simply so they be not forgotten. In regard to the question of variation of calorific value in quality with 24-hour charges, I have here a curve which shows the calorific intensity of the gas made by the plant at Vienna, showing variations from 500 to 830 B. t. u. when ten chambers were charged between 7 and 11 in the morning, and ten between 1 and 4 in the afternoon. I doubt very much if 24-hour charges, conducted only in the day time, would be acceptable to American conditions. If there were a large holder used in connection with it, the variation would not be small coming out of that holder, but I personally am not advocating very strongly the building of plants for 24-hour carbonization. In the first place, it will only be under very extraordinary conditions that it would pay to run on 24-hours in this country, inasmuch as the use of silica material allows from 16 to 20 hours carbonization with less expense than if you run on 24 hours coking time and save in labor. In regard to these analyses made at Sparrows' Point on the Barnhard apparatus, I am very much interested in what Mr. Way has to say about the ability of the carbonic acid pipette to give off oxygen. Those of us who have had experience in analyzing the gas coming out of the top of a superheater on a water gas machine, and finding 2.3 per cent. oxygen in it, if that oxygen has been put in by the carbonic acid pipette, why it is time some of us were finding it out. I am not at all sure that this explains anything in this instance, because as I recall it, at that time, great care was taken to change these solutions very frequently. In the Barnhard apparatus there is no shaking of the carbonic acid pipette, but the gas bubbles through the caustic and the sodium hypobromide, so that it may be possible that has the same effect as the shaking spoken about by Mr. Way. I can only say these are analyses taken by a man who has probably had as much experience in this country as any man in making analyses. They were made with great care, and I reported them as he took them. The explanation must

come afterwards, because while they do not check up in some instances, so far as I am concerned, I think the analyses are correct. The explanation must come on the case. For the analyses taken at Baltimore, I am indebted to Mr. Beadenkopf. They were taken by his chemist. They indicate a much lower percentage of nitrogen than what we found at Sparrow's Point, and I do not pretend to explain it. In regard to the size of the grain of coal as affecting coke, gas and by-products, I think Mr. Way is laboring under a misapprehension in regard to the policy of the Koppers Company. We have not changed our policy of pulverizing coal to make metallurgical coke, but we feel that the quality of the gas made from a coal is somewhat a function of the size of the grain, and in making gas in gas ovens for gas use to give 600 B. t. u. gas, we would not crush the coal as fine as though we were making metallurgical coke for blast furnace use on a coke oven.

MR. W. J. MCGURTY (New York): Having a high regard for the Koppers' Oven, as to its carbonizing efficiency, and also feeling that the isolated producers for heating settings are ideal, owing to the greater thermal efficiency attained, and to the lesser liability for flue stoppages, I think that the choice of carbonizing apparatus very often depends on the question of the disposal of residuals, particularly coke, and that for this reason, the retort will always hold its own.

I think that in comparing oven with retort operation, the bench, instead of the retort, should be considered the unit of comparison, and the comparison should be made with an efficiently operated through horizontal system rather than with the stop-end retort. While carbonizing systems producing results shown by the examples of "built-in" producers and "stop-end" retorts spoken of on pages 545, 546 and 555, may be in operation, local experience shows that the carbonizing results on through horizontals do not suffer by fair comparison with the oven, since a calorific multiple per pound of coal "as charged" of between 3,100 and 3,200 B. t. u. is obtained. On page 563, the retort is considered more as a means of storage

than as a gas producer, and a 15-foot through horizontal is taken as the example while 21-foot retorts are being operated. Therefore, an oven charge of 22,600 pounds per day would require

$$\frac{22,600}{900 \times 3} = 8.4 \text{ 15-foot horizontals or one bench on 8 hours,}$$

and

$$\frac{22,600}{1,550 \times 3} = 4.9 \text{ 21-foot retorts or 0.55 bench on 8 hours.}$$

Taking the bench as a unit instead of the retort, as the author has put the retorts on the same carbonizing period as the oven. The balance of this paragraph is a sad commentary on efficient supervision of heat regulation.

While the decomposition of ammonia in contact with hot coke, which has been quoted on page 598, may take place when the pure ammonia gas is used, the results of simultaneous ammonia and cyanogen tests made on a horizontal retort have not proved this contention under carbonizing conditions, since the ammonia present in the crude gas is considerably diluted and undoubtedly insulated by the other gases present. These tests showed that while the ammonia present during the third hour, when the maximum amount of cyanogen as gas per 100 cubic feet was observed, had decreased about 15 per cent. from the first to the third hour, the cyanogen content had increased about 54 per cent. From the third hour to the ending of the 8 hour period, the ammonia decreased a further 77 per cent. while the cyanogen content decreased 95 per cent.

MR. RAMSBURG: In regard to Mr. McGurty's point, page 563, in regard to the number of retorts, perhaps it would have been better to say, "Number of charges." The condition of the retort is the condition in regard to that individual charge. I think this correction is not well taken, but it is just as well to straighten it out so that it may not be misunderstood.

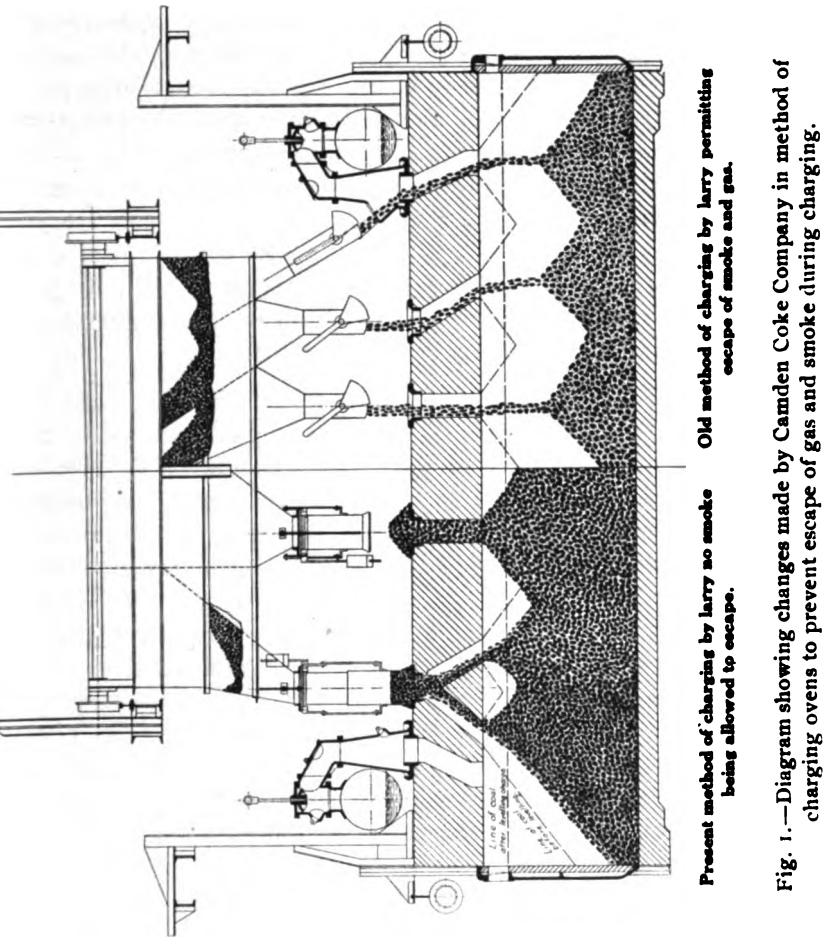
MR. E. C. WITHERBY (New York): I should like to say one word in regard to this paper. First of all, I want to con-

gratulate Mr. Ramsburg on his very excellent paper. It is an exceedingly appropriate one at this time, and I am sure the Institute is much interested in hearing the data he presents. The one point I want to mention is simply to emphasize what he says on page 568, about the market for coke. I think the impression might be gotten that carbonization in bulk in ovens is a simple problem for the production of gas in any locality. I should just like to emphasize the fact that it is essential to have an adequate market for coke in order to make the enterprise commercially successful.

MR. E. H. EARNSHAW (Newark): I had the privilege four years ago of seeing the construction of the gas ovens at Leopoldau described in this paper, and I can say that their design and workmanship was very good, and they looked to me then as if they probably would be extremely successful. The results quoted show that they have indeed been successful, and after reading Mr. Ramsburg's paper, one is tempted to believe that carbonization in gas fired ovens must be the best method. However, the reports of the Carbonization Committee, and especially the results reported by Mr. Taussig as having been obtained with verticals at Fall River and Hartford, show that no one system of carbonization has yet attained pre-eminent superiority and that there is still room for healthy argument as to the system to be adopted. It all comes down, as usual, to a consideration of conditions, the coke market, the kind of coke you want, the kind of gas you want, and other things, variable always, that go with the selection of any particular type of installation. There is another thing to remember, that it is apt to be misleading to compare, for American practice, results obtained in Europe by European practice. We have seen that with many methods of carbonization originating on the other side. Results may be better or worse, but they are not the same when the plants are installed and operated under American conditions.

There is one other point that hasn't anything to do with Mr. Ramsburg's paper, but may be of interest to the Institute.

**The Camden Coke Company** operates coke ovens in Camden, and a year or two ago it became a very urgent matter to do



something towards reducing the amount of smoke that occurred at the time of charging the ovens. In all coke ovens, the charging by larry into the charging holes allows the escape of a considerable quantity of gas and smoke, which in our case, be-

came obnoxious to the neighborhood, and it was necessary to do something, and the interesting part is that we have succeeded in developing a method whereby coal can be charged into an oven in an absolutely smokeless manner. It is interesting to know that, because it may be useful in other situations. Fig. 1 shows that the principle involved is that the charging holes through the floor of the oven should be supplied with coal at the top faster than it can be run out at the bottom, so that during the process of charging, there shall always be a plug of coal preventing the escape of gas. At the same time the valves to the two mains, the rich gas and the poor gas mains, are opened to offer a place for the escape of the gas that is formed in the ovens, and the result has been more than satisfactory. It has been practically perfect.

MR. J. H. TAUSSIG (Philadelphia): Through accident partly, and through the lateness of the publication of this paper, I did not receive it until yesterday morning. I have been trying ever since to properly digest and study it. I should like to say that Mr. Ramsburg has written a very complete paper, and he certainly puts the retort operating plant on the defensive, particularly in regard to fuel, at least it would seem so in reading his paper over hurriedly. However, there are some things that must be considered in this fuel economy. There is no doubt that there is a tremendous advantage in having such an efficient outside producer. Why the gas fraternity has not used this method in the past is beyond me. I am sure if I have the choice, the next plant I would build would have an outside producer plant. One of the great advantages gained, is that each unit has exactly the same quality of gas fuel. That means that the whole plant is working as a unit. The plant must be operated on a schedule of charges, and there is, undoubtedly, a saving if every unit is heated alike. Recently I asked a very well known gas engineer who has a horizontal plant, and who is having trouble with his producers, why he did not throw out these producers, take the bull by the horns and put outside producers in his plant? He said

he had just recently traveled through Europe, with the hope of seeing there such a plant. He said he saw only one, and this plant had an unequal distribution of heat in the retorts. It seemed to me a very poor reason for giving up a principle that had great advantages, simply because the first one seen was poorly worked out. It certainly would improve the conditions of the intermittent retort plant, either horizontal or vertical. I want to say a few words for the intermittent retort plants, particularly the vertical plants. I believe that in the same time and with less labor, as much coal could be charged and discharged as in any large coke oven. I should like to call attention to the fact that at Fall River two men per shift are charging and discharging retorts of a 1,000,000 ft. plant, are taking care of the furnaces and cleaning them, cleaning the stand pipes and doing everything about that plant except filling the coal and breeze bins and removing and screening the ashes from the producers. These men have more than half of their time to rest, and therefore, could easily, without any heavy labor at all, charge and discharge the retorts of a 4,000,000 or 5,000,000 ft. plant. There is still hope for the intermittent vertical retort system. We also have hope for the continuous system. (Laughter.) Mr. Ramsburg has spoken of the coke market. Undoubtedly, when a manager figures on the size of a plant, he figures how much coke can be disposed of. The lowering of requirements in candle-power and putting us on a heat units basis will naturally make us look forward to increase our coal gas plants. Therefore, the question coming up is how can we get rid of our coke? A by-product oven is out of the question. We want to make gas, we want to make lots of it and of good and uniform quality. Mr. Ramsburg has mentioned that in England, where they have no central heating plants in their houses, most of the market for coke is for open grate fires. In this country we have to be prepared to make a fuel that will displace in time anthracite coal for house furnaces, etc. I believe the recent tests have shown that the coke made in intermittent types of vertical retorts is



almost identical with the same coal, as that made by the by-product coke oven, and that being the case, the study of the future will be, which plant, making an equal quality or quantity of coke, can get the most out of a ton of coal? I cannot see how a unit, with all the joints a coke oven has, can keep in as good condition over a period of time and make as good quality of gas as a retort. I should, therefore, like to ask Mr. Ramsburg if he has any records of tests made on a coke oven after it had been in operation for a number of years. My attention was called recently to coke oven plants which have been run a certain length of time, where the nitrogen contained in that gas was high. Can we take the risk in supplying a large city with run of oven gas from a coke oven, after it has been in operation for a period of time?

MR. RAMSBURG: In regard to Mr. Taussig's statement, the last question as to the nitrogen, these ovens are built with silica material. The silica material expands until it reaches a temperature approximately of 2,100 degrees. After that point, until it reaches a temperature of 2,700 degrees, the curve of expansion and contraction is practically a straight line. Under those conditions, with the oven brought up to a temperature of over 2,100 degrees, and the buckstays tightened, kept tightened and tension put on them (as they are in properly operated plants), the silica material is always under compression. The silica bricks are tongue and grooved bricks and the ovens remain tight. I have no hesitancy in saying that even operating on high volatile coal, if proper attention is paid to keeping the buckstays tight, that the plant will operate with less than 5 per cent. of nitrogen for a great many years. The plant of the Illinois Steel Company at Joliet was built of silica, the first plant in this country, and was built according to the plant made for German coals, and it has been operating since 1908. This is the sixth year. They have not replaced a brick in those silica batteries, excepting some small repairs in the end walls. I will give the exact figures in the notes, but my impression is that the nitrogen at the present time

from the battery of ovens is less than 6 per cent., although I believe no attempt is made to keep the nitrogen down.

MR. W. H. GARTLEY (Philadelphia): I want to emphasize one point that Mr. Earnshaw has made, which has been corroborated in my own experience, and that is that local conditions have so much to do with the selection of what sort of carbonizing plant you use. Several other instances of local conditions, such as coke market and so on, have been mentioned, but I want to mention one other: Mr. Taussig and I are both employed by the same company. The company is showing a willingness to build a vertical intermittent system, as you may have imagined from hearing Mr. Taussig. Immediately the largest company under their control puts in a horizontal system, and that is just an illustration I want to bring out how local conditions will govern the selection of a system. We selected the horizontal system because we had a building; we were using other horizontal benches; we tore out one stack and put in another. If we had not had the building or had decided that the cost of the operation of that portion of the old style of settings that were left and which we intended to use, in connection with the cost of operation of a new system such as the vertical, which would be operated from another floor and so on, could have been economical, we probably would have been influenced to the extent of changing our selection of the carbonizing method.

I would like to say just one thing about silica material. It has been a very great surprise to me in the last 10 months to see what that material will do as compared with fire-clay for those places in which it is possible to use silica material. In 10 months, in forty-five retorts, 29 ft. long, under fire, there hasn't been any indication that we can see anywhere of a crack or a warp of any sort. With the advice and assistance of these two gentlemen here, Mr. Earnshaw and Mr. Ramsburg, we had experience with the fire clay in horizontal retorts for years, and to come across a material that will stand up as silica material does is almost unbelievable. Then again, you will

find that the conductivity of the heat through the silica material is very much more apparent in practice than that of the fire clay, and we are able to carbonize per lineal foot of retort a great deal more coal than we expected to do. In fact, we figured we would do very well if we were able to continue to carbonize 70 lbs. of coal per lineal foot of retort in 8 hours. That would be 4,500 lbs. of coal in the whole retort for 24 hours. We find we can carbonize 5,200 lbs. We can do that without, as I say, in 10 months—that is the limit of our experience—having any trouble at all or any indication of overheating, warping, cracking or anything of that kind.

THE ACTING CHAIRMAN: Is there any further discussion? Mr. Ramsburg, have you any remarks to make?

MR. RAMSBURG: I think not, Mr. Chairman.

THE ACTING CHAIRMAN: This meeting will reconvene at 2 o'clock.

Adjourned, 12:53 P. M.

## MANUFACTURING SECTION.

Afternoon Session, Thursday, October 22.

MR. H. L. UNDERHILL (New York), *Acting Chairman*,  
Presiding.

MR. W. VAN ALAN CLARK (Astoria, Long Island, N. Y.),  
*Section Secretary*.

The Acting Chairman called the meeting to order at  
2.20 P. M.

THE ACTING CHAIRMAN: The first paper this afternoon is  
"Methods and Facilities for Specifying and Testing Blowers,  
Also Measuring Air and Steam Supply to the Water Gas Gen-  
erators," by Mr. J. M. Spitzglass, of Chicago.

### METHODS AND FACILITIES FOR SPECIFYING AND TESTING BLOWERS ALSO MEASURING AIR AND STEAM SUPPLY TO THE WATER GAS GENERATORS.

We are well aware that atmospheric air and water in the form of steam are raw materials which are usually supplied to the water gas generator in unknown and poorly regulated quantities. The air for blasting is usually gauged by the blast pressure under the grate, and the steam for gas making is gauged by the pressure at the inlet to the generator. But as the resistance which the fuel bed offers to the flow of air varies from time to time, the flow through the generator varies accordingly. Without providing the means to regulate that variation it becomes very difficult to keep the machine running uniformly, and to adjust the amount of steam to correspond with the variable air blast quantity.

It is fortunate that some of the irregularities resulting from the unknown variation of the flow are balanced by the large amount of heat stored up in the fuel bed of the generator. But for the reason of the high fuel bed, the task of getting results from the fuel is very complicated, and it could be much simplified if means were provided for measuring and regulating the flow of air and the flow of steam into the generator.

In some places flow meters, or the equivalent, are provided for measuring the air blast; but unless the blower is properly adjusted for the purpose, and adequate means are provided for regulating the flow, the utility of the meter is very limited.

It is the object of this paper to discuss the characteristic properties of the centrifugal blower as adapted for blasting the water gas machine; to formulate methods and facilities for specifying and testing the blower; and to suggest means for regulating the flow of air and adjusting the flow of steam into the water gas generator.

#### CHARACTERISTIC PROPERTIES OF THE CENTRIFUGAL BLOWER.

In discussing the action of the blower, perhaps the most important item in securing the proper service for blasting is a thorough understanding of the peculiar properties to which the centrifugal apparatus is subjected. A familiarity with these properties is necessary in order to be able to specify the proper blower for the given condition, and to determine the later performance of the blower. In what follows an attempt will be made to explain the principles underlying those properties.

The delivery of fluid by the centrifugal blower is purely incidental to the action of the rotating blades. The prime function of the blades is to set the fluid particles in rotary motion around the center of the impeller, thereby creating, in the region of the rotating medium, an outward tension due to the centrifugal action of the rotating particles. The blower primarily builds up a pressure by rotating the fluid, and incidentally discharges a corresponding volume when openings are provided in the casing and the fluid is allowed to escape. In this respect the pressure of the centrifugal blower is analogous to the volume of the displacement blower. In the latter machine, when the speed of the blower is increased the discharged volume increases without regard to the pressure. In the former, when the speed of the impeller is increased the pressure increases without regard to the volume, within certain limits.

*The Action of the Centrifugal Force.*

The centrifugal action manifested by the particles of the rotating fluid is not the same type of centrifugal force that is exerted in a revolving solid body, such as a circular plate or flywheel. In the solid body the centrifugal force exists only as an internal stress or tendency, which is not acting, and, therefore, it involves no additional expenditure of energy on the revolving body by its existence in the body. In the revolving fluid, however, the centrifugal force is active, compressing the fluid particles and raising their potential energy by an amount equivalent to the rotary motion of the fluid. Accordingly, each particle of the revolving fluid possesses, by virtue of the same motion, a double portion of energy as compared with an equal particle of a revolving solid. Of this energy, one part is kinetic, and is equivalent to the velocity of the particle; the other part, being of the same magnitude, is potential, and is imparted to the particle when it is raised to the equivalent pressure by the acting centrifugal force.

*Potential and Kinetic Energy Imparted to the Fluid Particles.*

From the well known relation of the units by which the two forms of energy are measured, we have as a general expression:

$$E = \frac{V^2}{2g} \gamma \text{ (kinetic energy)} + p \text{ (pressure)} = \frac{V^2}{g} \gamma \text{ (total energy)} \dots (1)$$

Where E is the total amount of energy in foot pounds imparted to a cubic foot of the fluid when passing through the blades of the impeller.

V is the tangential velocity, in feet per second, of the fluid leaving the blades. For radial blades V is equal to the peripheral velocity of the impeller.

g is the gravity unit of mass, equals 32.2.

$\gamma$  is the density of the fluid in pounds per cubic foot, and

P is the pressure generated by the centrifugal force

which is also equal to  $\frac{V^2}{2g} \gamma$ .

From the nature of the two forms of energy imparted to the fluid particles by the action of the blades, the potential energy of the centrifugal action appears directly in the form of pressure which is utilized to overcome the resistance to the flow of the fluid delivered by the blower. Of the kinetic or velocity energy, however, only a part can be retained and converted into useful work. If the particles of the fluid, upon leaving the blades, are given the proper direction, as determined for the blower, the part of velocity transposed into pressure is considerable, and the blower is operated with higher efficiency. When this direction is changed, the part of the velocity energy transformed into pressure decreases, and the efficiency of the blower is greatly reduced.

A change in the quantity of fluid delivered by the blower produces a corresponding change in the ratio of kinetic to potential energy, and also changes the direction of the particles leaving the blades of the impeller, thereby effecting the efficiency of the blower and the pressure developed by a given peripheral speed. This is illustrated graphically in the accompanying figures, Nos. 1 to 6 inclusively. In each figure, showing the elementary sketch of a centrifugal blower, the distance  $r$  represents to scale the peripheral velocity of the impeller, and the arrow head lines represent to the same scale the velocity of the fluid in the given direction.

In Fig. 1 the outlet from the blower is closed. The impeller running with a velocity  $V$ , imparts to the fluid the potential energy  $\frac{V^2}{2g} \gamma$ , and also the velocity energy of the same magnitude in the direction  $a-b$  tangent to the periphery of the blades. Since there is no delivery from the blower, the velocity energy is theoretically transformed into pressure so that the total pressure in the casing should be  $\frac{V^2}{g} \gamma$ .

Suppose in a given case it is found that the total pressure when the discharge valve is closed is equal only to  $\frac{V^2}{2g} \gamma$ ; that

FIG. 1.

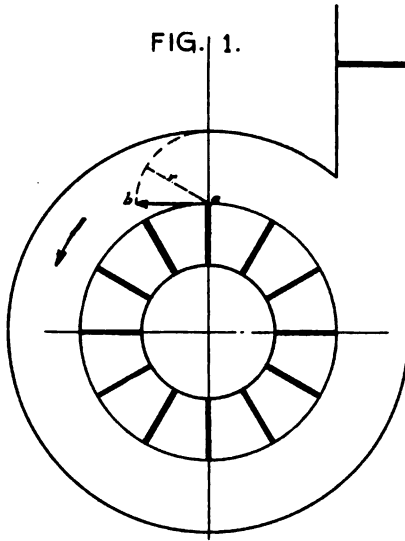


FIG. 2.

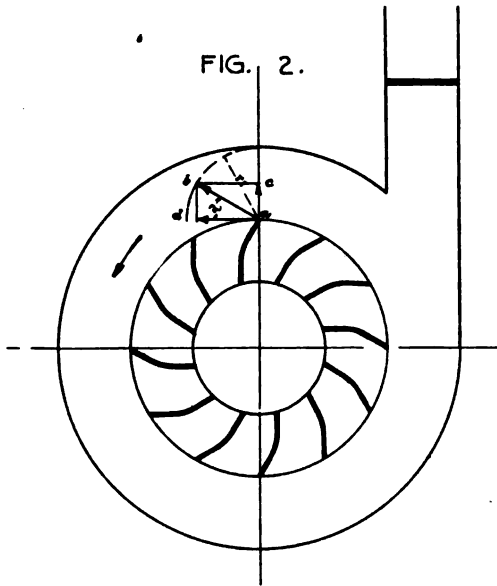




FIG. 3.

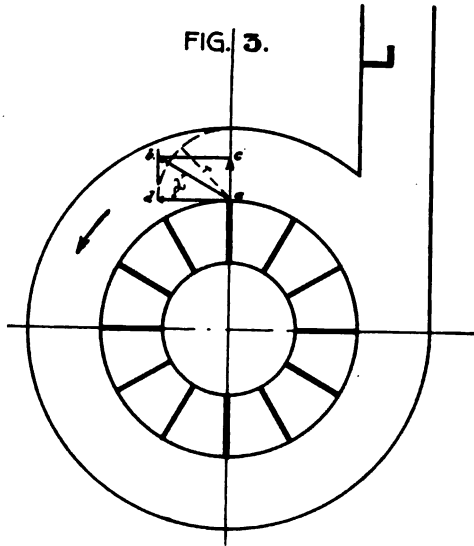


FIG. 4.

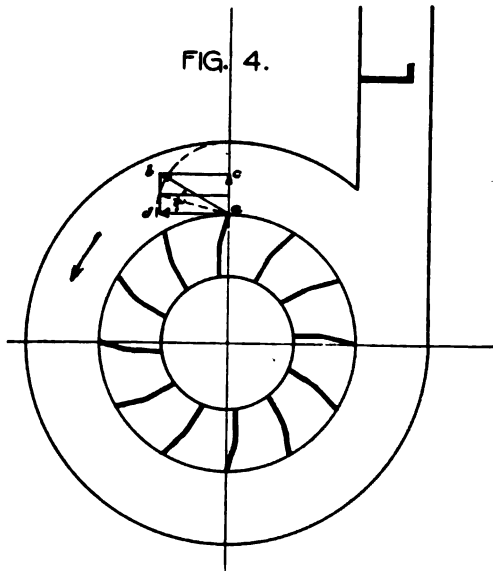


FIG. 5.

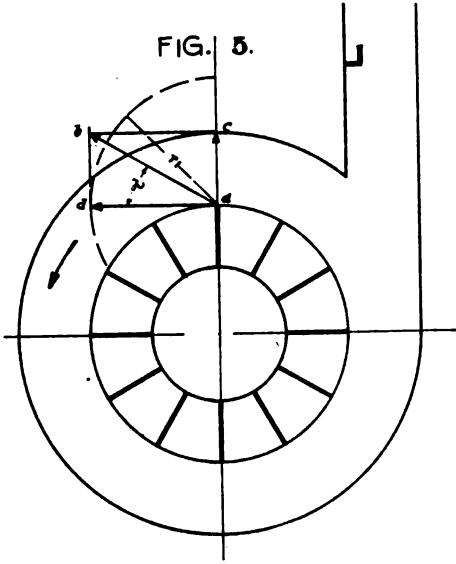
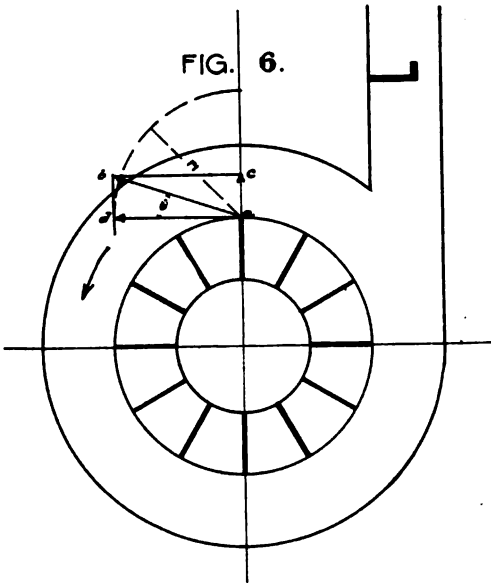


FIG. 6.



is, if we find that all the velocity energy of the fluid is absorbed in eddy currents and shock losses in the casing, then we change the direction of  $a-b$  to follow from the periphery of the blower with an angle  $\alpha$  that will reduce gradually the velocity of the fluid in the casing after leaving the blades of the impeller, and will transfer as much as possible of the velocity energy into pressure.

The change of direction of the line  $a-b$  to follow the proper angle  $\alpha$  can be effected either by curving the blades so as to make the radial resultant of the velocity equal to  $a-c$ , as shown on Fig. 2, or by discharging a volume from the blower such that will make the actual radial velocity of the fluid equal to  $a-c$ , as shown on Fig. 3, or by a combination of the two, as shown on Fig. 4. It will be noticed that curving the blades reduces the energy input on the fluid by decreasing the tangential component  $a-d$  and diminishing the action of the centrifugal force. In either case the effect produced, as shown graphically on the given figures, remains the same only for the same speed and the same quantity discharged from the blower.

The effect of increasing the speed of the impeller for the same angle of discharge is shown in Fig. 5, where  $r_1$  represents the peripheral velocity of the blades, and where the radial velocity is increased in the same proportion as the tangential velocity of the fluid. This indicates that in order to maintain the same efficiency, the flow must be increased in proportion with the increase of the speed. If additional resistance is put on the outlet so as to discharge with the increased speed a volume equal to that of Fig. 3, the angle of discharge is changed, as shown on Fig. 6, and the efficiency of the blower is reduced.

#### *The Characteristic Curve of the Blower.*

Thus we see that there is a definite relation between the volume discharged from the centrifugal blower and the static pressure developed in the casing by a given speed of the impeller. Consequently a certain definite resistance to the

flow must accompany each given discharge of the blower, and, inversely, a definite discharge must correspond to a given resistance. This relation between the volume discharged by the blower and the resistance or static pressure that must accompany the given discharge is called the characteristic property of the centrifugal blower, and a curved line, showing on a co-ordinate diagram, the relation of the two quantities for a given speed of the impeller is called the characteristic curve of the blower.

*Characteristic Curve for Variable Discharge.*

Fig. 7 shows a typical characteristic of a centrifugal blower

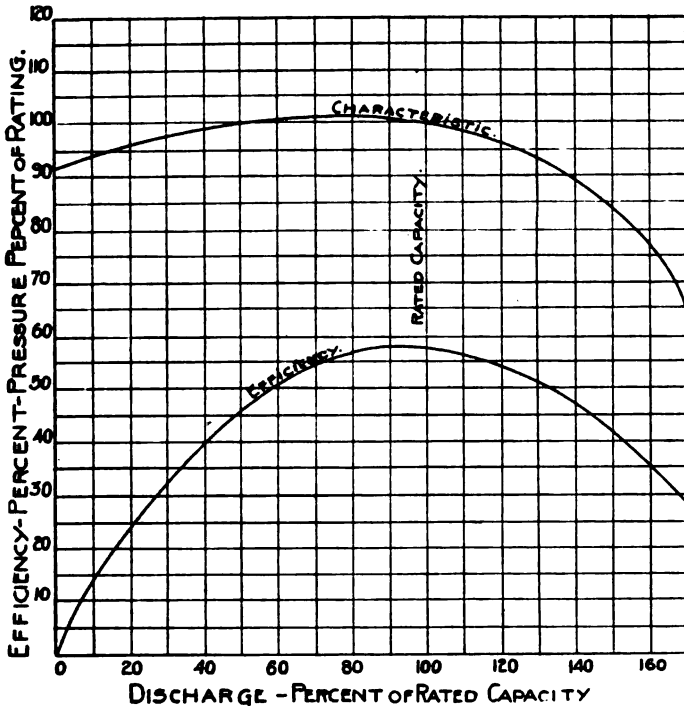


Fig. 7.—Typical characteristic for variable discharge.

or compressor designed to deliver a variable quantity of air or gas at a given uniform pressure. The discharge of the

blower is shown in per cent. of the rated capacity, which is the volume delivered by the blower with the highest efficiency, and the corresponding pressure is given in per cent. of the pressure developed by the blower when discharging the rated capacity volume. At zero discharge this blower develops a certain pressure corresponding to the speed of the impeller, and when the flow is started the pressure rises gradually with the increase of the volume to about 80 per cent. of the rated capacity, and then drops uniformly until the maximum capacity of the blower is reached.

For the largest portion of the curve the pressure is nearly constant, and for this purpose the inherent property of the blower to develop a predetermined pressure for a given speed of the impeller, or the characteristic of the blower, is utilized directly for regulating the pressure and to take up the fluctuations of the volume delivered. The regulation is sufficient for all practical purposes, a variation of only 3 per cent. from the rated pressure being shown between 20 per cent. load to 20 per cent. over-load in the volume. If the speed of the impeller is increased the pressure will rise accordingly, but the variation will remain nearly the same for all speeds the blower is designed for.

#### *Change to Constant Volume.*

If the blower represented by this characteristic (Fig. 7) were to be used for blasting a water gas machine, where the uniformity in the volume is a great deal more important than the uniform pressure, it would necessitate some device to keep the volume constant, otherwise the slightest increase in the resistance of the fuel bed would reduce the supply of air to the machine considerably. Such a device would keep the volume constant by varying the pressure in the line in one way or another. This would mean that after the blower was designed to possess the property of holding the discharge pressure nearly constant, a costly device would be added to counteract that property and to vary the pressure in order to keep the volume constant.

It is well to mention at this point that the constant volume device, even if it were economical, would not answer the purpose for blasting the water gas machine. As a matter of fact it is not practical at all to have the flow of air into the machine strictly constant even during a single run, considering the necessary variation in the quantity of secondary blast. If the total amount of both primary and secondary were kept constant it would greatly diminish the capacity of the machine by reducing the primary blast for the later part of the blow when the fuel is able to take care of more air. If the primary blast alone were kept constant it would effect a similar reduction in capacity because the primary blast would have to be lowered in order to keep the blower working within the given limits of blast pressure. What is actually wanted is a uniform delivery of air during each period increasing the total volume gradually towards the end of the blow.

#### *Pressure and Volume Regulation.*

A step in the right direction for regulating the air blast into the generator is to have the blower develop a characteristic similar to the one shown on Fig. 8. At zero discharge the blower develops the maximum pressure for the given speed, and when the flow is started the pressure is decreased considerably, but gradually with the increase of the discharge quantity. With this characteristic, the blower inherently possesses a pressure and volume regulating property which is more suitable for the operation than either the constant pressure or the constant volume regulator.

What this characteristic actually does is to make both, the pressure as well as the volume, to take up a part of the variation or change in the existing condition. If the resistance offered to the flow is increased, tending to decrease the volume, the corresponding increase in discharge pressure tends to overcome the additional resistance with the result that the volume is not materially reduced and the rise in pressure is only moderate. With the admission of the secondary blast more freedom is allowed to the flow, and a larger total volume

corresponds, as it should for utilizing the machine to the best advantage.

One objection to the shape of this characteristic is that the pressure increases considerably at zero discharge of the blower. At certain times it is desirable to keep the blower

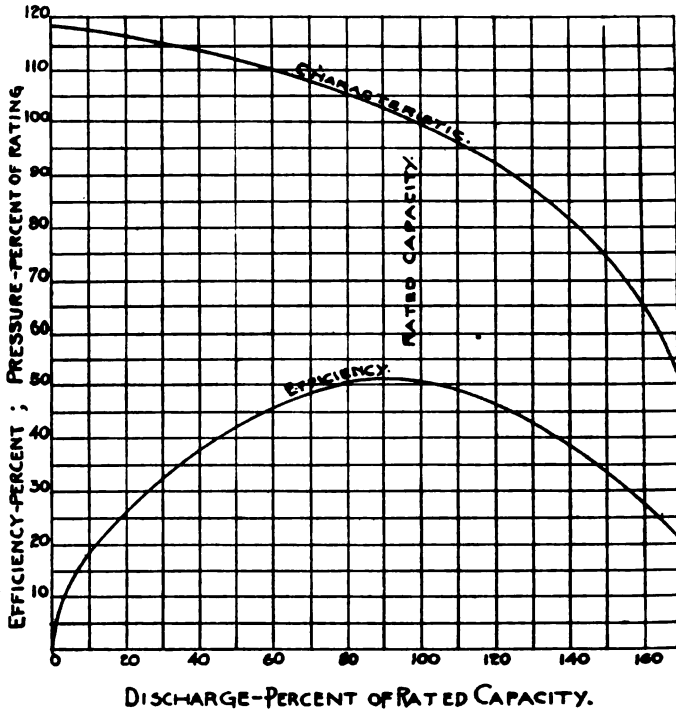


Fig. 8.—Typical characteristic for pressure and volume regulation.

running during the period of gas making, and in such cases the increased pressure increases the noise and works additional hardship on the blades and mechanism of the blower. When the blast is shut off every run, the starting and especially the stopping of the blower works harder with the increase of the pressure at zero discharge.

#### *Double Type Characteristic.*

To overcome the difficulty of excessive pressure at zero dis-

charge it is advisable to have the characteristic of the blower shaped as shown on Fig. 9. From zero discharge to about 70 per cent. of the rated capacity the discharge pressure is nearly constant, and from 70 per cent. to the maximum capacity the pressure decreases considerably with the increase in the volume discharged by the blower. With this characteristic, how-

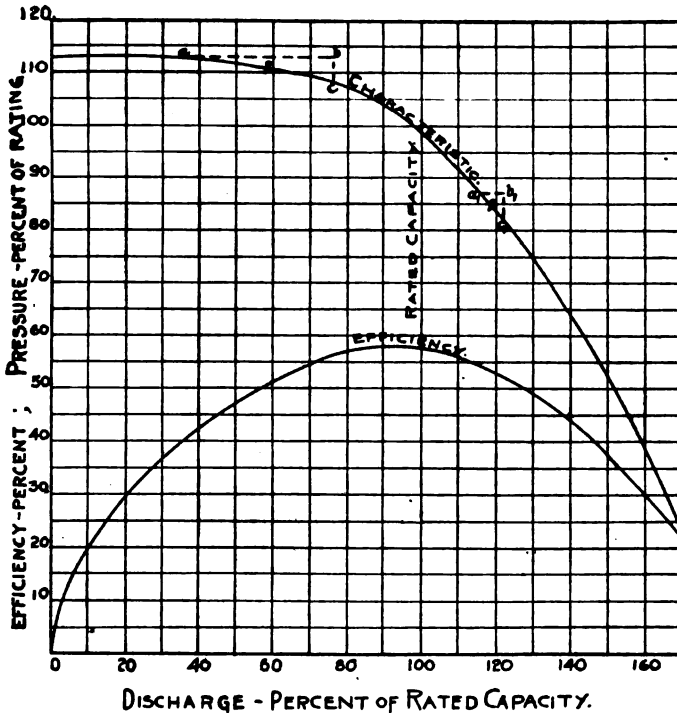


Fig. 9.—Typical double type characteristic.

ever, special care must be taken to have the actual discharge of the blower as close as possible to the rated capacity, or at least not lower than the rated capacity, otherwise if the discharge strikes the horizontal part of the curve, the whole regulation is lost, and the variation is taken up by the volume alone, the latter decreasing considerably with the increase of resistance in the line.



It will be noticed that the characteristic curve of Fig. 9 represents in the first half the shape given in Fig. 7 and in the second half the shape of Fig. 8. That is to say, the blower represented by this characteristic has the property of constant pressure regulation for the first half, or the lower volumes, and the property of pressure-volume regulation for the second or higher volumes of discharge. The difference between the two, or the influence of the shape of the characteristic upon the regulation of the flow from the blower is emphasized on this figure by the dotted lines joining the points  $a-b-c$  and  $a_1-b_1-c_1$ . In both cases it is assumed that the resistance in the line was increased by the same amount as indicated by the length of the lines  $c-b$  and  $c_1-b_1$ . Accordingly the flow will adjust to a new position  $p$  having a mean value between  $a$  and  $b$  in the first case and between  $a_1$  and  $b_1$  in the second case. The diagram shows the comparative change produced in the volume in either case.

#### SPECIFICATIONS FOR THE BLOWER.

Having determined upon the shape and value of the general characteristic of the blower adapted for blasting the water gas generator, we can proceed now to formulate a method for specifying the blower when it is necessary to order one. As a rule the manufacturer will always live up to the specifications if he is given a chance to understand what is wanted.

The quantities to be considered in specifying the blower are:

- A—The rated capacity of the blower in cubic feet of free air per minute.
- B—The pressure in inches of water corresponding to the rated capacity of the blower.
- C—The average barometer and air temperature at the inlet to the blower.
- D—The range of speed in revolutions per minute through which the blower will safely operate with the given efficiency.
- E—The mechanical efficiency of the blower at the rated capacity.

### *The Rated Capacity.*

The rated capacity refers to the volume of air the blower will deliver against the given resistance with the highest mechanical efficiency. This volume is specified in cubic feet of free air at standard conditions, which is equivalent to specifying a given weight of air to be compressed and delivered by the blower.

To determine the amount of air to be specified for a given case: Suppose it is desired to order an individual blower for a 12 ft. water gas generating set, having an inside diameter of 9 ft., or a grate area of 63.6 sq. ft. At first it is necessary to assume the rate of gas production of the generator, or the amount to be produced per square foot of grate area.

The make per square foot of grate area is a great deal a matter of personal opinion and practice of the manager of the gas works. Some people think that 1,800 cu. ft. of gas per square foot of grate area per hour is a sufficient make for the gas machine, and they would not try to increase the make in order not to impair the oil efficiency of the generator. Others seem to think that higher makes are accompanied by higher oil efficiency. The writer had a chance to witness a test on two Williamson machines where a continuous make of 2,700 ft. per hour of actual operation (blowing, gas making and charging) was maintained for a full month, with a satisfactory oil and candle-power efficiency. For our figuring we will assume that the make is to be 2,500 cu. ft. per hour of actual operation. Multiplying 2,500 by 63.6 we have the total make of the machine per hour equal to 159,000 cu. ft.

The second step is to determine the quantity of air that should be allowed per 1,000 cu. ft. of gas produced by the machine. Figuring an average of 32 lbs. of coke or coal per M and deducting ashes and unburned carbon 15 per cent. the amount of pure carbon consumed per M is—

$$32 \times 0.85 = 27.2 \text{ lbs.}$$

The weight of carbon retained in the finished gas, figuring 30 per cent. of CO and 4 per cent. of CO<sub>2</sub>, is—

$$340 \times 0.032 = 10.9 \text{ lbs.}$$

(0.032 is the weight of carbon per atom in 1 cu. ft. of gas.)

The amount of carbon consumed during the blast is, therefore,—

$$27.2 - 10.9 = 16.3 \text{ lbs. per M.}$$

To find the amount of air per pound of pure carbon we have as an average analysis of blast products from a water gas machine.

	Per cent.
CO <sub>2</sub> .....	15.5
CO .....	5.0
O <sub>2</sub> .....	0.5
N <sub>2</sub> .....	79.0
Total .....	100.0

The weight of the constituents carbon and nitrogen in 100 cu. ft. of blast gases when reduced to standard conditions will be—

Carbon : 20.5 (volume) times 0.032 (atomic weight) = 0.656 pounds

Nitrogen : 79.0 (volume) times 0.0742 (atomic weight) = 5.860 pounds

The weight of nitrogen per pound of carbon is—

$$5.86 \div 0.656 = 8.94 \text{ lbs.}$$

and pounds of air per pound of carbon is—

$$8.94 \div 0.77 = 11.6 \text{ lbs.}$$

Air per 1,000 cu. ft. of finished gas is, therefore—

$$11.6 \times 16.3 = 189 \text{ lbs.}$$

One pound of free air has a volume of 13.1 cu. ft.

$13.1 \times 189 = 2,480$  cu. ft. of air per 1,000 cu. ft. of gas produced by the generator.

In some cases it may be necessary to vary the quantities assumed in this computation and for this purpose the diagram on Fig. 10, based on the method illustrated here, will offer a ready solution for the quantity of air required per 1,000 cu. ft.

of gas for all cases within the limit of practical conditions of operation. The equation solved by the diagram is—

$$Q = 17(C-11) \frac{74.2N_2}{32(CO_2+CO)} = 39.45(C-11) \frac{N_2}{CO_2+CO} (2).$$

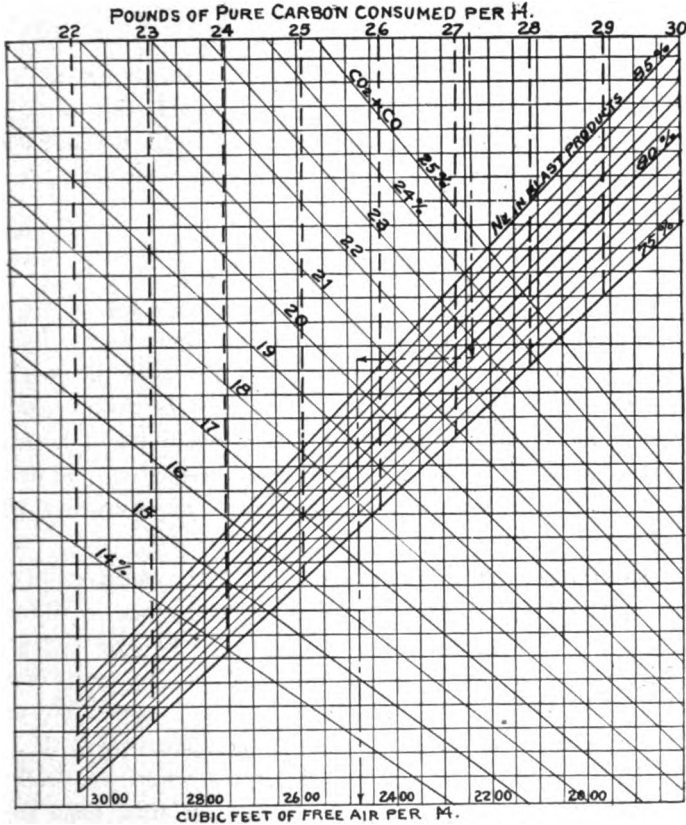


Fig. 10.—Showing air blast required per M. Example indicated by arrow-heads.

Given carbon per M..... = 27.2 lbs.  
 Given  $N_2$  per M ..... = 79.0 per cent.  
 Given  $CO_2 + CO$  per M... = 20.5 per cent.  
 Air required per M as solved = 2,480 cu. ft.

Where C represents the pounds of carbon consumed per 1,000 cu. ft. of gas.

$N_2$ ,  $CO_2$ , and CO represent the per cent. of those constituents in the analysis of the blast products from the water gas machine.

As the generator in our case is to produce 159,000 cu. ft. of gas per hour it will require  $159 \times 2,480 = 395,000$  cu. ft. of air per hour of actual operation. If the hour is to be divided into 7 cycles of 8 minutes each, the blasting time will occupy 28 minutes. Dividing 395,000 by 28 we have the average amount of air to be delivered by the blower, 14,100—say 14,000 cu. ft. of free air per minute.

#### *The Static Pressure.*

The pressure to be developed at the rated capacity of the blower depends upon the resistance to the flow offered by the fuel bed, checker bricks and passages through the various compartments of the generator. In most cases this resistance has to be assumed by reference to other machines of the same type and using the same kind of fuel, as the only way to determine the actual resistance is by a test of the operation after the blower is installed.

In referring to other machines of a given type it is well to keep in mind the manner in which the resistance is accumulated or the blast pressure is distributed through the machine. In Fig. 11 are shown three diagrams of blast pressure distribution in water gas generators of the same type, but with different size connections between the compartments. It will be noticed that in No. 1 and No. 2 diagrams, where the machine had smaller connections, 50 per cent. of the total blast pressure was lost in the passages, while in No. 3 diagram where the connections were larger, the drop wasted is only 22 per cent. of the total. This may emphasize by the way that the builders of water gas generators should appreciate the importance of avoiding unnecessary resistance in the passages and outlet of the machine, considering that the power necessary

to deliver a given volume of air increases in proportion with the resistance against which it has to be delivered.

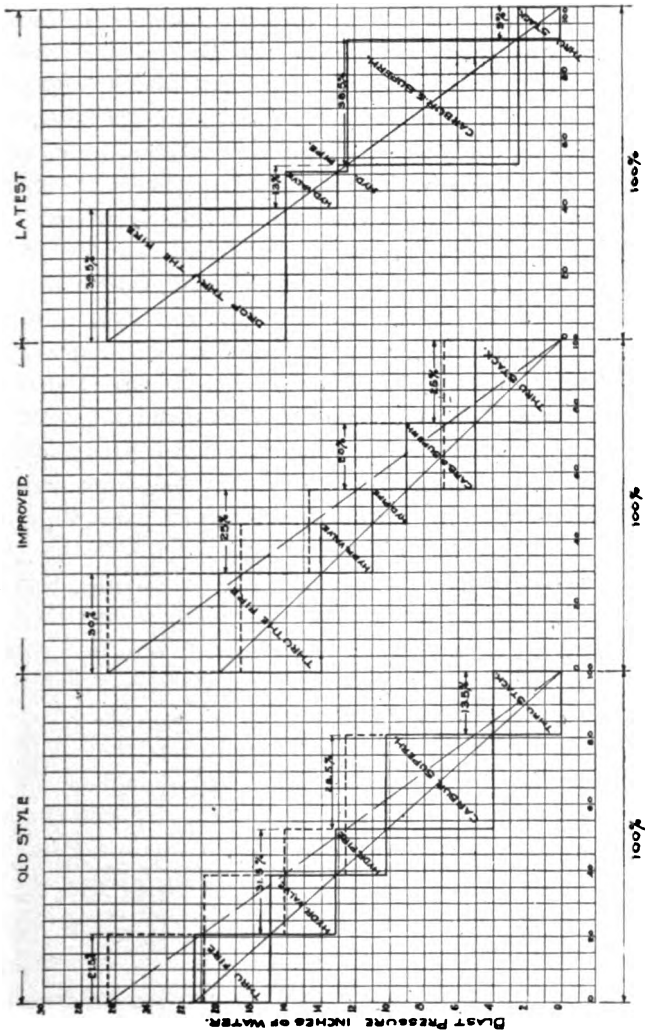


Fig. 11. — Distribution of blast pressure in Williamson Gas Generators.

By referring to our previous discussion about the effect of changing the volume, and also to the efficiency curves plotted

with each characteristic on Figs. 7, 8 and 9, it will be realized that for efficient operation it is necessary to run the blower as close to the rated capacity as possible. As the resistance that will correspond with the proper volume cannot be definitely determined it is advisable to specify for the rated discharge of the blower the most probable pressure that may be expected by reference to other machines of the same type. If the specified pressure will prove to be too high for the rated volume, the running of the blower will be adjusted to the right of the characteristic curve with the volume somewhat increased. If the specified pressure will not be sufficient for the rated capacity, the adjustment will be to the left of the characteristic curve, with the volume somewhat diminished. In the case we are illustrating here, for instance, we would specify a volume of 14,000 cu. ft. per minute to be discharged against a continuous resistance of 26 in. of water pressure.

While specifying the pressure for the rated capacity of the blower it is advisable also to make certain about the desired characteristic, or the pressures that would correspond to other volumes and the static no delivery pressure of the blower. This can be done either by referring to a curve of the desired shape or by specifying the approximate increase of pressure to correspond with the decrease of volume, and vice versa. If a shape similar to Fig. 3 were desired it could be stated that the static no-delivery pressure should be not over 20 per cent. higher than the rated pressure, and the rate of change from 80 per cent. load to 20 per cent. over-load should be about 1 per cent. change of pressure against 1 to  $1\frac{1}{2}$  per cent. change of volume in the opposite direction. In this item the manufacturer should be held responsible only for the general shape of the characteristic, the exact rate of change not being essential for the operation.

#### *Air Inlet Conditions.*

The barometric pressure and the temperature determine the density of the air at the inlet to the blower. Upon this density depends the weight of air delivered and the pressure

developed by the blower. That is to say, the weight in a given volume, or the amount of standard cubic feet delivered by the blower, and the pressure developed at a given speed of the impeller are directly proportional to the density of the air at the inlet to the blower.

The general specification implies that the action of the blower is gauged by the standard cubic foot of air, and therefore, unless the pressure and temperature at the inlet to the blower are specified and agreed upon, the manufacturer is entitled to correct the density for standard conditions at the inlet just the same as the purchaser is correcting the volume for standard conditions at the outlet.

The temperature of the air and the barometer to be specified depend upon local conditions. In our case, for instance, we would specify 29.5 in. for the barometer and 85° F. for the temperature of the air at the inlet to the blower.

#### *The Speed of the Blower.*

The speed of the blower refers to the peripheral velocity of the blades, which determines the pressure or the characteristic of the blower. For a given size of blower the revolutions per minute are usually specified, signifying the same as the peripheral speed, since the active diameter is constant. It should not be understood, however, that the peripheral speed of the blades is the only criterion that makes up the characteristic. If two blowers not having the same diameter of impeller blades are operated at the same peripheral speed, all other things being equal, the one with the larger diameter will develop a higher static pressure than the other for even quantities of discharge because the radial velocity is diminished with the larger diameter. Usually a larger width of the impeller would accompany the larger diameter, thus making a larger size blower.

These points are all worked out in detail by the manufacturer, and when the pressure-volume conditions are specified by the purchaser the proper size is easily determined, and the revolutions per minute will be the only unit that has to



enter the guarantee for this purpose. That is, the manufacturer will be held responsible for the specified pressure and volume at the speed in revolutions per minute he had indicated for the blower. For our illustration we will assume that the manufacturer indicated the speed of 2,500 r. p. m. for the blower to deliver the rated capacity (14,000 C. F. M.) against 26 in., with a possibility of increasing the speed 250 r. p. m. if desired.

### *The Efficiency.*

The efficiency of the blower is the ratio of the energy developed by the blower in moving and compressing the given volume of air, to the energy supplied to the blower by the driving appliance. It is usually specified for the rated capacity of the blower, being stated either as the ratio of the air horse-power to the brake horse-power, or directly as the brake horse-power necessary to deliver the given volume at the specified pressure.

To determine the efficiency of the blower it is necessary to take into consideration the method of driving. If a motor drive is used the determination is comparatively easy. With an engine or turbine drive it becomes more complicated, and a combined efficiency of blower and drive must be stated in order to be of any value. For our illustration we will assume that the blower is to be turbine driven and an efficiency of not less than 50 per cent. was guaranteed for the rated capacity of the blower, this to be coupled with a guarantee for the turbine to develop a brake horse-power per 36 lbs. of steam at 150 lbs. gauge when running non-condensing with a back pressure of 5 lbs. gauge.

### *Summary of Specifications.*

To summarize the specifications for the illustrated case: The turbine driven blower is to deliver 14,000 C. F. M. of free air against a continuous resistance of 26 in. of water when running at a speed of 2,500 r. p. m. (The speed of the blower can safely be increased to 2,750 r. p. m.) Air inlet

conditions to be 85° F. temperature, and 29.5 in. barometer. The mechanical efficiency of the blower is to be not less than 50 per cent. at the rated capacity and specified speed, figuring a brake horse-power for each 36 lbs. of steam consumed by the turbine from 150 lbs. gauge initial pressure to 5 lbs. gauge back pressure. The characteristic of the blower should show a decided drop in pressure from 80 per cent. of the rated capacity to the maximum discharge. The static no delivery pressure should not be more than 20 per cent. higher than the pressure developed at the rated capacity.

#### TESTING THE BLOWER.

After the blower is installed and the operation is started it is necessary to run a commercial test in order to verify the specifications for the acceptance of the blower. However, this verification should not be considered the main object of the test. Moreover, the fact that manufacturers usually live up to specifications should not influence the purchaser to avoid the trouble of testing the blower. The main object of the test should be to determine the actual performance of the blower in order to make certain that it is operated at all times on the proper section of the characteristic curve.

#### *Pitot Tubes for Measuring the Volume of Air.*

To measure the volume of air during the test a method has to be employed upon which the seller and purchaser have previously agreed in the specifications. The method most commonly employed is one or another form of pitot tubes recognized by the two parties as a standard for measurement. It is well to know, however, that the different forms of pitot tubes do not always agree in their indication of a given flow. The pitot tube is actually made up of two little tubes introduced into the pipe one pointing against the flow and the other at right angles to the flow, the two tubes being connected at some distance from the pipe, by a water gauge acting as a seal and indicating the differential pressure caused by the

impact of the flow. If each tube is led to a separate gauge, the one pointing against the flow will indicate the true total pressure, including the static or bursting pressure in the pipe and the velocity pressure of the flow, while the other tube will indicate the true static pressure only if placed in the pipe exactly so as to avoid the slightest effect of the flow upon the opening of the tube. This is where the difference comes in between the various forms of pitot tubes. They all show identically the same total or dynamic pressure in a given flow, but they do not all show the same static pressure, some forms indicating the effect of suction by the flow decreasing the static pressure and others indicating the effect of partial impact increasing the static pressure indicated by the gauge.

The difference between the known forms of pitot tubes for air measurement is discussed at length and well pointed out by W. C. Rowse (see "Pitot Tubes for Air Measurement" by W. C. Rowse, *Journal of the A. S. M. E.*, Sept., 1913) who experimented with a number of tubes including the Taylor standard tube with slotted static openings, the A. B. C. pitot tube with very small static openings, and the Gebhardt tube with beveled static openings. Mr. Rowse found that the true static pressure was indicated only by the small openings of the A. B. C. static tube, and this pitot tube compared accurately with a Thomas electric gas meter which was used as a standard of measurement. Of the other tubes, the Taylor pitot tube indicated about 10 per cent. less volume than the Thomas meter, and one of the Gebhardt tubes indicated about 7 per cent. less than the same meter.

This discussion brings out the fact that it is immaterial which form of pitot tube is used for testing, as long as we know the correction factor from one form to another, or the proper coefficient for the given tube. For instance: if the Taylor tube indicates 1,000 cu. ft. of air it is equivalent to 1,100 cu. ft. indicated by the A. B. C. tube, or 1,000 cu. ft. by the A. B. C. tube are equivalent to 910 cu. ft. by the Taylor tube. This, of course, has to be considered at the time of the

purchase and the proper coefficient as well as the form of the pitot tube has to be agreed upon in the specifications.

*The Mean Velocity in the Pipe.*

It is understood that the differential pressure indicated by the pitot tube is equivalent to the impact at the point where the dynamic opening is facing the flow. The latter is very much retarded nearer to the perimeter of the pipe, the velocity of the gas at the various points of the cross sections if drawn to scale assuming the shape of a parabola with the focus at the center of the flow. The ratio of the mean velocity in the pipe to the maximum, indicated by the tube placed in the center, is considered by some to be a constant quantity. The directions accompanying the Taylor tube specify that the mean velocity over the full area of the pipe equals 0.91 times the velocity indicated by the tube placed at the center of the pipe. With the Gebhardt tube it is specified to place the dynamic tube at a distance  $R$  from the center usually taken as 0.8 times the radius of the pipe, and for exact calculations a method is given to determine the actual value of  $R$ , or the point where in a given case the actual velocity equals the mean velocity over the full area of the pipe. With the A. B. C. tube the method to be followed is to divide the area of the pipe into a number of concentric annular areas and to take a reading at the center of each annular area. For all practical purpose it is sufficiently accurate to take the average of the readings as the mean velocity head in the pipe. If great accuracy is desired the square roots of the readings have to be averaged and the square of this average represents the mean velocity head, since the velocity at each point varies as the square root of the velocity head at that point.

*Figuring the Results of the Test.*

In conducting the test of the blower the main problem is the systematic arrangement and proper figuring of the results. This figuring is somewhat complicated, as it involves the changes produced in the air by the various pressures and tem-

peratures. To facilitate the figuring of the test and with the intention of recommending the use of the pitot tube more extensively the writer devised a set of diagrams for the graphical solution of the quantities involved in the figuring. For the satisfaction of those who would like to check up the given equations, and also believing that it will interest the reader, the liberty is taken to discuss the fundamental theory of the pitot tube calculations.

### *The Theory of the Pitot Tube.*

When the flowing particles of the air are brought to rest impinging against the opening of the dynamic tube, the kinetic energy, or the motion of those particles is transposed into potential energy in the form of pressure developed inside the dynamic tube. The relation of the pressure developed in the tube to the velocity of the impinging particles is expressed in the fundamental equation:

$$\frac{V^2}{2g} \gamma \text{ (rate of impact) } = P \text{ (Developed pressure) } \dots (3)$$

Where  $V$  is the velocity of the air in feet per second.

$g$  is the gravity unit of mass, equals 32.2.

$\gamma$  is the density of the air in pounds per cubic foot

$P$  is the equivalent pressure in pounds per square foot

From equation 3.

$$\frac{V^2}{2g} = \frac{P}{\gamma} \dots \dots \dots (4), \text{ and}$$

$$V = \sqrt{\frac{2gP}{\gamma}} \dots \dots \dots (5)$$

When the impact of the flow is balanced by a column of liquid of a known density and height, the pressure per square foot exerted by the balancing column is equal to the height in feet times the density in pounds per cubic foot, or

$$P = HW \dots \dots \dots (6)$$

$H$  and  $W$ , representing the height in feet and density in

pounds per cubic foot of the liquid balancing the impact of the flow, and equation (6) is changed to the form of

$$V = \sqrt{\frac{2gHW}{\gamma}} \dots\dots\dots (7)$$

Equation 7 is the most convenient form for solving the velocity of a fluid when the pressure of impact is counter-balanced by the height of a liquid column. For a column of water at 60° F. 1 ft. of water height is equal to 62.4 lbs. per square foot, and 1 in. of height is equal to  $62.4 \div 12 = 5.2$  lbs. per square foot, and equation 7 takes the form of

$$V = \sqrt{\frac{2gh \times 5.2}{\gamma}} = 18.30 \sqrt{\frac{h}{\gamma}} \dots\dots\dots (8)$$

and the mean velocity in feet per minute

$$V_m = 60 CV = 1098 C \sqrt{\frac{h}{\gamma}} \dots\dots\dots (9)$$

where  $h$  is the height of the column in inches of water balancing the velocity pressure, and  $\gamma$  is the density of the flowing air in pounds per cubic foot.  $C$  is the ratio of the mean velocity to the maximum, or the co-efficient of the pitot tube.

It is the general custom in making these calculations to begin with the hydraulic formula.

$$\frac{V^2}{2g} = H \dots\dots\dots (10)$$

Where  $H$  is an imaginary column of the flowing air that will balance the pressure of the impact. This form being correct in principle and easily applicable in hydraulic problems, is not convenient for solving the flow of air. In the first place it involves a term which is unnecessary for the problem adding useless work in the figuring. In the second place it leads to erroneous conclusions about the effect of the non-homogeneous density of the imaginary column upon figuring the value of the velocity in the pipe. It is usually forgotten that the column of air is only imaginary and that the impact formed by the air of known and homogeneous density in the pipe is balanced by a liquid also of known density, and no matter what the

density of the imaginary column is, the equilibrium is obtained between two known quantities and, therefore the fundamental equation (3) holds true for all velocities of the air in the pipe.

In explaining this, the writer refers to a theory stated by Mr. F. H. Kneeland (Jour. A. S. M. E., Nov., 1911, p. 1407) that for high velocities of the air in the pipe the equation giving the velocity of the air corresponding to the differential pressure of the pitot tube is to be modified by the expression

$$\sqrt{1 - 0.355 K + 0.202 K^2 - 0.137 K^3}$$

where  $K$  is the ratio of the velocity pressure to the absolute static pressure in the pipe. The modification means that for a given differential pressure indicated by the tube the energy of the flow is equal only to the amount necessary to compress the air adiabatically from the lower to the higher pressure, which amount is less than the potential energy of the differential column. This could not be true, because if a mass of known density,  $\gamma$ , is moving with a given velocity,  $V$ , it

possesses an amount of kinetic energy equal to  $\frac{V^2}{2g} \cdot \gamma$ . irrespective of the thermodynamic action that took place when the velocity was originally formed, and when this kinetic energy is balanced by a pressure  $WH$ , then  $\frac{V^2}{2g} \cdot \gamma$  must equal  $WH$  otherwise there would be no equilibrium in the line.

#### *Calculating the Volume of Free Air.*

To figure the velocity of the air from equation (9) we have to determine the value of  $\gamma$ , the density of the flowing air in pounds per cubic foot.

The density of air at 60° F. and 29.92 in. of mercury is 0.0764 lb. per cubic foot. At any other temperature and pressure, (from Charles Low):

$$\begin{aligned} \gamma_2 &= \frac{0.0764 \times (460 + 60) \times (B_1 + H_1 \div 13.6)}{(460 + t_2) \times 29.92} = \\ &= 1.325 \frac{(B_1 + H_1 \div 13.6)}{460 + t_2} \dots\dots\dots (11) \end{aligned}$$

Substituting this value of  $\gamma_2$  for  $\gamma$  in equation 9, we have

$$V_2 = 1098 C \sqrt{\frac{h}{1.325 (B_1 + H_1 \div 13.6) \div 460 + t_2}}, \text{ or}$$

$$V_2 = 954 C \sqrt{\frac{h (460 + t_2)}{S}} \dots \dots \dots (12)$$

Where  $V_2$  is the mean velocity of the air in feet per minute;

$C$ , is the ratio of the mean velocity to the maximum, or the coefficient of the pitot tube.

$h$ , is the height of the differential, in inches of water

$H_1$  is the static pressure in the line, inches of water

$B_1$  is the barometric pressure, inches of mercury

$t_2$  is the temperature of the air in the pipe degrees Fahrenheit.

$$S = B_1 + H_1 \div 13.6.$$

The weight of air  $G$ , in pounds per minute, flowing through a pipe of cross sectional area  $A$  square feet :

$$G = V_2 \gamma_2 \quad A = 1098 CA \gamma_2 \sqrt{\frac{h}{\gamma_2}} = 1098 CA \sqrt{h \gamma_2} \dots (13)$$

Substituting the value of  $\gamma_2$  from equation 11 we have ;

$$G = 1098 CA \sqrt{\frac{1.325 (B_1 + H_1 \div 13.6) h}{(460 + t_2)}} =$$

$$1263.8 CA \sqrt{\frac{hS}{(460 + t_2)}} \dots \dots \dots (14)$$

The volume of air  $Q$ , in standard cubic feet per minute,

$$Q = \frac{G}{0.0764} = 16542 CA \sqrt{\frac{hS}{460 + t_2}} \dots \dots \dots (15)$$

For a pipe of diameter  $D$ , in inches

$$A = \frac{0.7854 D^2}{144} \dots \dots \dots (16)$$

Substitute the value of  $A$  in equation 15.

$$Q = \frac{16542 \times 0.7854}{144} CD^2 \sqrt{\frac{hS}{460 + t_2}} =$$

$$90.15 CD^2 \sqrt{\frac{hS}{460 + t_2}} \dots \dots \dots (17)$$



A method for the graphical solution of equation 17 is given on the accompanying diagram No. 12.

*Air Horse-Power.*

The energy, or work, in foot pounds, developed by the blower is equal to:

Cubic feet of air at intake, times mean effective pressure in pounds per square foot.

For a blast pressure up to 3 lbs. per square inch the mean effective pressure is practically the same as the total or dynamic pressure in the line at the outlet from the blower. The work in foot pounds developed by the blower is, therefore,

$$W = 5.2Q_1H_2 \dots\dots\dots (18)$$

and the air horse-power of the blower is

$$\text{H. P.} = \frac{5.2Q_1H_2}{33,000} \dots\dots\dots (19)$$

Where  $Q_1$  is the volume of air in cubic feet per minute entering the blower, and  $H_2$  is the dynamic pressure in the line, inches of water. (5.2 is the pressure in pounds per cubic foot equivalent to 1 in. of water head.)

The relation of the inlet volume  $Q_1$  to the standard volume  $Q$  is

$$\frac{B_1Q_1}{460 + t_1} = \frac{BQ}{460 + 60} = \frac{30Q}{520} \dots\dots\dots (20)$$

or

$$Q_1 = \frac{30}{520} \times Q \frac{(460 + t_1)}{B_1} \dots\dots\dots (21)$$

where  $B_1$  and  $t_1$  represent the barometric pressure and the temperature at the inlet to the blower in inches of mercury and degrees Fahrenheit respectively.

Substitute the value of  $Q$  in equation (19)

$$\text{Air H. P.} = \frac{5.2 \times 30Q(460 + t_1)H_2}{520 \times 33,000B_1} = \frac{Q(460 + t_1)H_2}{110,000B_1} \quad (22)$$

A method for the graphical solution of equation 22 is given on the accompanying diagram No. 13.

# DIRECTIONS

FOR *Follow the Diagram in order indicated on Fig. 12*

*b, S, t, C, D, Q*

Where: Q - Air

C - Co Use Lower or Higher Set, according to magnitude of "b"

D - Dia

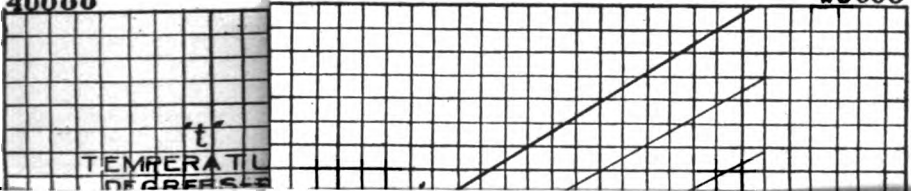
b - Hgt Read "Q" in cubic feet per minute, in Set. identical with "b"

S - Stat

t - Temp

40000

20000



# THE HISTORY OF THE CITY OF BOSTON

FROM THE FIRST SETTLEMENT IN 1630 TO THE PRESENT  
BY  
JOSEPH NEALE, ESQ.  
OF THE BARR

LONDON: PRINTED BY J. JOHNSON, ST. PAULS CHURCH-YARD, 1773.

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## DIRECTIONS:

FOR  $S$  follow the Diagram in order indicated  
on Fig 13;  $Q, H_s, t_i, B, HP$ .

WHERE:  $HP$  - Air  $H_s$  of  $Q$  and  $H_s$ , can be multiplied or divided by  
 $Q$  - Static factor of 10. In such a case  $HP$  should be changed  
 $H_s$  - Dynamic product of the two factors.  
 $t_i$  - Inlet  $t_i$  is multiplied and  $H_s$  divided by the same  
 $B$  - Barometer, or vice versa,  $HP$  remains unaltered.



*Correction for Air Inlet Conditions.*

If during the test the barometric pressure and the temperature of the air at the inlet to the blower are different from those specified by the purchaser, the volume discharged by the blower and the static pressure are subject to a correction corresponding to this difference of pressure and temperature.

This correction factor is the ratio of the air density at the specified conditions, to the actual density of the air at the inlet to the blower.

$$\gamma : \gamma_1 = \frac{B_s}{460 + t_s} : \frac{B_1}{460 + t_1} \dots \dots \dots (23)$$

and the correction factor

$$f_1 = \frac{\gamma}{\gamma_1} = \frac{B_s (460 + t_1)}{B_1 (460 + t_s)} \dots \dots \dots (24)$$

Where  $B_s$  and  $t_s$  are the specified, and  $B_1$  and  $t_1$  are the actual barometer and temperature for the air inlet to the blower.

*Correction for Difference in Speed.*

Another correction may be necessary during the test if the speed of the blower was not kept the same as the one specified. By reference to Fig. 5 of this work it will be noticed that for a given direction of the air from the blades, the radial velocity varies in the same proportion as the peripheral velocity of the blades, or the quantity discharged is in proportion with the speed of the impeller. The pressure developed varies with the square of the tangential velocity, or with the square of the speed. For the volume, the correction factor is the ratio of the specified speed to the actual speed, and for the pressure the factor is the ratio of the squares of the same speeds, or

$$f_1 = \frac{R_s}{R} \text{ and } f_2 = (f_1)^2 \dots \dots \dots (25)$$

Where  $f_1$  is the speed correction factor for volume, and  $f_2$  is the speed correction factor for pressure;  $R_s$  is the specified speed of the impeller, and  $R$  is the actual speed, both in revolutions per minute. It is advisable, however, to avoid the use

of these factors by running the blower at the speed given in the specifications.

The amount of moisture in the air or the relative humidity has no effect upon the final results of the test, as any difference in humidity corrects one way at the inlet to the blower and the opposite way at the outlet. Since the absolute amount of moisture present in the air does not change by going through the blower, the two corrections balance each other and do not have to be considered.

#### *Procedure of the Test.*

The procedure of the test is as follows: The blower is started to operate at the specified speed. The pitot tube is inserted in the pipe preferably at a distance of over 10 diameters from an elbow or bend in the line. For more accurate results the differential gauge should be of the inclined type commonly used for measuring the draft in boiler furnaces. The static pressure is measured by a water gauge, and the amount of static pressure desired is adjusted by opening or closing the outlet from the pipe into the atmosphere. Several sets of readings are taken at desired intervals of static pressure, beginning with zero discharge of the blower, and ending with a pressure a few inches lower than the one specified for the rated capacity of the blower. It is not essential to take readings for the exact pressures specified for the rated capacity, as the characteristic curve of the test will necessarily cross that point.

#### *Arrangement of Data and Results.*

In running a test in general it is advisable to label each item to be used in the figuring by a letter mark which would represent the same item throughout, thereby avoiding a great deal of repetition. The following will serve as a guide for the figuring of the blower test with letter marks of the items as employed in this work.

Item	Mark	Stands for	Equivalent to
1	R <sub>s</sub>	Rated speed, R. P. M.	Specified
2	Q <sub>s</sub>	Rated C. F. M.	Specified
3	H <sub>s</sub>	Pressure inches of water at rated capacity	Specified
4	B <sub>s</sub>	Specified barometer	Specified
5	t <sub>s</sub>	Specified temp. for inlet air	Specified
6	W <sub>s</sub>	Steam rating for turbine, pounds per brake horse power	Specified
7	R	Actual R. P. M.	Average data from log sheet
8	W <sub>1</sub>	Steam consumption of tur- bine, pounds per hour	Average data from log sheet
9	D	Diameter of blast pipe, in.	Given
10	C	Co-efficient of pitot tube	Given
11	t <sub>1</sub>	Room temperature °F.	Average data from log sheet
12	t <sub>2</sub>	Flow temperature °F.	Average data from log sheet
13	B <sub>1</sub>	Barometer, inches mercury	Average data from log sheet
14	H <sub>1</sub>	Static pressure	Average data from log sheet
15	h	Velocity pressure	Average data from log sheet
16	H <sub>2</sub>	Dynamic pressure	H <sub>1</sub> + h
17	S	Absolute static, inches mercury	B <sub>1</sub> + H <sub>1</sub> ÷ 13.6
18	Q	Standard C. F. M. flowing through the blast pipe	$90.15CD^2 \sqrt{\frac{hS}{460 + t_2}}$ (This equation can be solved graphically by diagram No. 12)
19	f <sub>1</sub>	Air inlet factor	$\frac{B_s(460 + t_1)}{B_1(460 + t_s)}$
20	f <sub>2</sub>	Speed correction factor for volume	$\frac{R_s}{R}$



Item	Mark	Stands for	Equivalent to
21	$f_s$	Speed correction factor for pressure.	$(f_s)^2$
22	$Q_f$	Equivalent volume	$Q f_1 f_s$
23	$H_f$	Equivalent static pressure	$H_1 f_1 f_s$
24	AHP	Air horse-power of blower	$\frac{Q(460 + t_1)H_s}{110,000B_1}$ (This equation can be solved graphically by diagram No. 13)
25	BHP	Brake horse-power	$\frac{W_1}{W_s}$
26	$e$	Mechanical efficiency	$\frac{AHP}{BHP}$

To make the table complete it may be well to include the following quantities; however, their solution is not necessary for the figures of the test.

Item	Mark	Stands for	Equivalent to
27	G	Total weight of air in pounds	0.0764Q
28	$\gamma_1$	Density of the air in the blast pipe pounds per cubic foot	$\frac{1.325B_1 + H_1 \div 13.6}{460 + t_1}$
29	$V_1$	Mean velocity of the air, feet per minute	$954C \sqrt{\frac{h(460 + t_1)}{S}}$

The accompanying table shows the figures of a typical test for the case of our illustration, arranged in the above outlined order. Diagram No. 14 shows the characteristic curves plotted from the figures given in the table. The curves show that the blower is well up to specification and that practically the same efficiency is obtained between 90 per cent. and 110 per cent. of rated capacity.

#### REGULATING THE SUPPLY OF AIR TO THE GENERATOR.

It was said at the start that the main object of the test should be to determine the actual performance of the blower, and to make certain that it is operated at all times on the

TABLE 2. SHOWING DATA AND RESULTS OF BLOWER TEST

SPECIFIED RATING: CAPACITY (Q) 4000 CFM; SPEED (R) 2500 RPM; STATIC PRESSURE (H<sub>s</sub>) 26 INCHES OF WATER  
 SPECIFIED CONDITION FOR AIR AT INLET; TEMPERATURE (T<sub>i</sub>) 85°F; BAROMETER (B) 29.8 INCHES MERCURY  
 TURBINE RATING: STEAM PER BRAKE HORSE POWER (W<sub>b</sub>) 16 POUNDS FROM 150 GAUGE TO 5 POUNDS BACK PRESSURE.

DATE NUMBER	STEAM POUNDS PER HOUR	R.P.M.	BLAST DIA. INCHES	TUBE COEF.	INLET TEMP. DEGREES F.	FLOW TEMP. DEGREES F.	BAROMETER	STATIC PRESS. INCHES OF WATER	VELOCITY PRESS. INCHES OF WATER	PISTON PRESS. INCHES OF WATER	ABSOLUTE STATIC PRESSURE IN POUNDS PER SQUARE INCH	CFM STANDARD	AIR INLET CORRECTION	SPEED CORREC. FOR VOLUME	SPEED CORREC. FOR VOLUME	DISK VOLUME	EQUIV. PRESS.	AIR H. POWER	STEAM H. POWER	COMBINED ETC.
1	1585	2500	24"	0.41	40	95	29.80	29.8	0	29.80	31.39	0	1.02	100	100	0	304	0	44.0	0
2	2310	2500	"	"	110	"	29.20	0.03	29.73	30.35	30.40	"	1.00	100	100	5200	298	40.90	92.0	74.50
3	2650	2600	"	"	110	"	29.25	0.05	29.15	30.18	30.40	"	1.00	100	100	10700	298	62.40	107.0	48.00
4	4425	2600	"	"	105	"	27.10	1.29	28.38	30.28	30.50	"	1.00	100	100	12600	27.7	60.1	117.8	51.00
5	4550	2600	"	"	100	"	26.30	1.61	27.91	30.13	30.50	"	0.99	0.98	0.98	14500	26.8	67.4	129.1	52.80
6	5040	2600	"	"	100	"	24.10	2.10	26.80	30.97	30.70	"	1.00	1.00	1.00	16400	24.6	72.1	147.5	57.00
7	5720	2500	"	"	100	"	21.95	3.25	26.30	30.68	30.50	"	1.00	1.00	1.00	18400	22.4	77.8	158.7	46.00

proper section of the characteristic curve. In order to accomplish this a pair of home-made pitot tubes is inserted in the blast pipe before the running of the test. The tubes are to be left permanently in the pipe for future index and they can be either of the single opening type shown in Fig. 15, or of

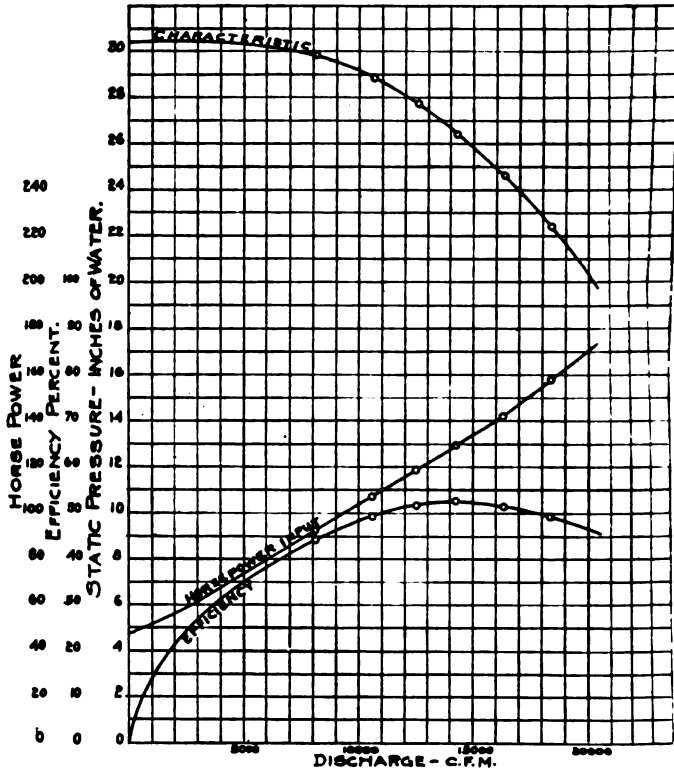


Fig. 14.—Characteristic curves of blower test.

the multi-opening type shown in Fig. 16. In either case both tubes are identically the same, but one is pointed against the flow, taking in the total or dynamic pressure, the other is pointed from the flow, taking in the static pressure diminished by the syphoning action of the flow upon the openings of the tube. By arranging the tubes in this manner a larger differ-

ential pressure is obtained for the same velocity in the pipe, and this differential is just as proportional to the flow of air in the pipe as is the velocity head of the testing pitot tube. The single pitot tubes placed in the center will give the highest differential for a given flow. It was the experience of the writer, however, that the multi-opening tubes are more posi-

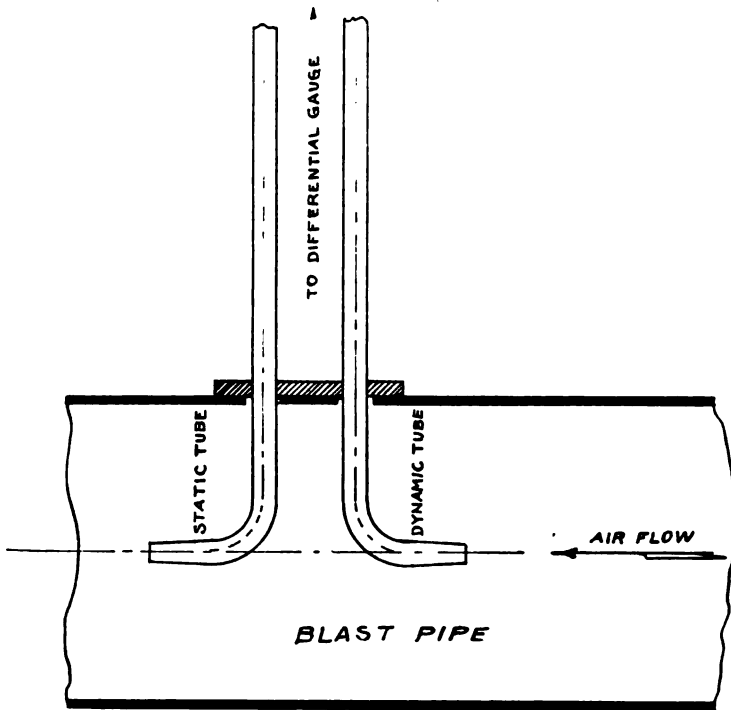


Fig. 15.—Single opening pair of pitot tubes.

tive; they can be relied upon with greater certainty, and they are also the easiest to be aligned in the proper direction.

From the tubes, pipe connections are led to the two ends of a U tube, or differential water gauge, placed at the gas maker's desk. Here is a point that wants to be impressed very emphatically: There should be no trap or pocket in the line between the tubes and the water gauge. This may be taken as a rule

for the low pressure gauges in general, that it is better not to have the gauge at all than to have it connected so that a pocket or trap for water may be formed in the line. This is especially true when the connections are led from condensable vapors.

If the connections from the tubes to the differential gauge are air-tight and clear, a difference in height of the water column will be formed in the gauge in proportion to the flow

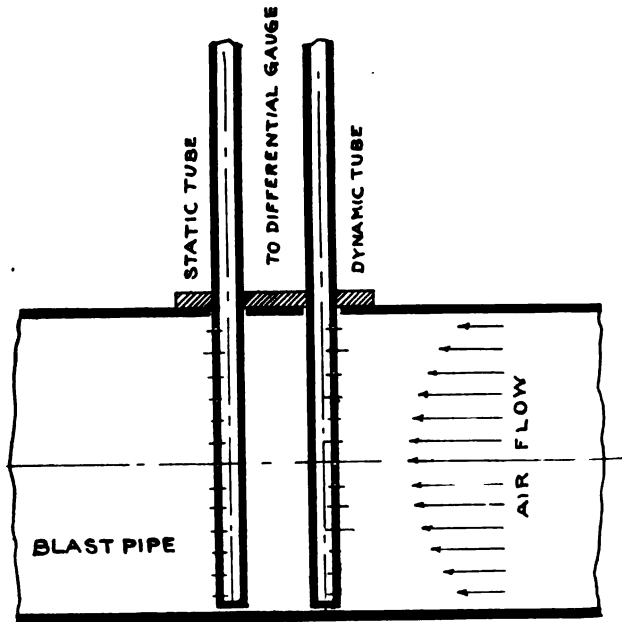


Fig. 16.—Multiopening pair of pitot tubes.

of air in the pipe. Approximately the coefficient of the single opening tubes to be substituted for  $C$  of equation 17, will be about 0.73 and the coefficient of the multi-opening tubes will be about 0.75. (Lines for these two values of  $C$  are given on Diagram No. 12.) For our case, however, the value of the coefficient is immaterial because the tubes are to be used only as a relative index of the flow of air referred to the volumes obtained with the highest efficiency during the test. If desired,

corresponding readings can be taken on this gauge during the test and a calibration curve drawn for the permanent pitot tubes to read directly in cubic feet of air for the height of water column in inches. It is sufficient, however, to note the differential column of the permanent pitot tube gauge, only for the rated volume of the blower, or close to that volume.

The diagram on Fig. 17 shows the per cent. of variation of

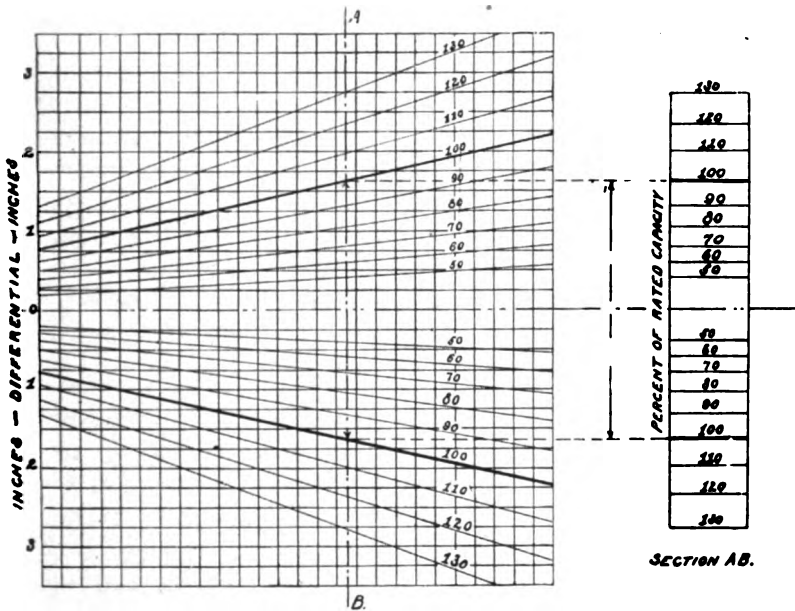


Fig. 17. —Per cent. of rated capacity corresponding to change in height of differential column.

a given flow corresponding to the change of height in the differential column formed by any given type of pitot tubes. The diagram is layed out to be used for a regular U tube water gauge with a zero level in the middle of the tube, and the 100 per cent. volume lines are drawn for a total height from 2 in. to 4 in. of water column.

When the differential column corresponding to the rated

volume of the blower is noted, a vertical line is drawn across the diagram at a point to make the distance between the two 100 per cent. volume lines equal to that differential column. This is illustrated by the section A-B drawn on the diagram and forming a scale reading in per cent. of the rated or desired volume corresponding to the differential column  $h$ . In the same manner a scale for any other differential can be laid out and posted on the rule of the gauge which will indicate at all times the variation of the flow of air in the pipe.

When the machine is started in operation, the differential gauge of the pitot tubes will indicate at once the relation of the actual resistance in the machine to the volume delivered by the blower at the given speed. If the actual resistance is less than the assumed or specified resistance, the gauge will show a higher volume, and vice versa, if the actual resistance is higher than the one specified, the gauge will show a lower volume than the rated capacity of the blower at the rated speed. In either case the per cent. of volume increased or decreased will be indicated by the differential gauge.

With the characteristic of the blower to vary the pressure and the volume in opposite directions, the difference in volume will be insignificant unless the assumed resistance of the machine was very much different than the actual. If this should be the case the speed of the blower may have to be changed to correspond with the actual resistance and the desired volume of air to be delivered. The change of speed will also change the volume and, therefore, the same efficiency will be maintained in the operation.

The indication of the pitot tube differential gauge enables the gas maker to maintain a uniform flow of air into the generator at all times. If a considerable change is noted in the column it will be traced either to an occasional change in the speed of the blower or to an abnormal increase of resistance in the machine which can be removed if desired or the speed of the blower can be changed to deliver the desired volume.

### REGULATING THE SUPPLY OF STEAM.

Passing now to the regulation of steam into the generator it is necessary at first to establish a relation between the amount of steam and the amount of air to be delivered to the machine.

Basing the proportion upon the make of 1,000 cu. ft. of gas, 30 lbs. of steam for 2,500 cu. ft. of air will represent a fair average in operation. If the blasting and the running periods are 4 minutes each, figuring 14,000 cu. ft. of air blast per minute each run will require,  $\frac{14,000 \times 4 \times 30}{2,500} = 672$  lbs. of steam per run, or 168 lbs. per minute to be delivered to the generator.

#### *Measurement of Live Steam.*

If the machine is operated with live steam, the best method of measuring and regulating the steam is to insert in the pipe,

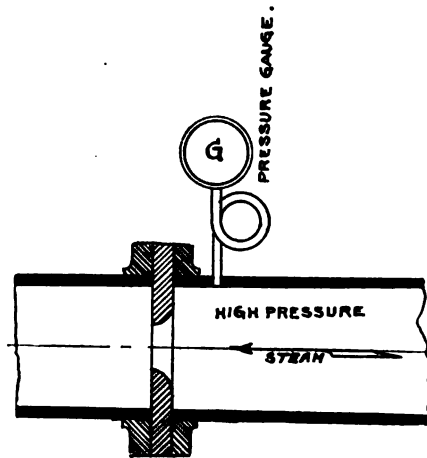


Fig. 18.—Disc orifice for measuring live steam.

close to the generator, a disc with an orifice of a known diameter. The orifice should be well rounded on the inlet side of the disc (see Fig. 18) and the diameter should be



small enough, and the size of pipe large enough, to build up a high differential pressure between the 2 sides of the disc.

When the absolute pressure in front of the disc is more than  $\frac{5}{8}$  of the absolute pressure immediately after the disc the weight of steam discharged through the orifice depends upon the initial pressure only, and for a given size of orifice the weight of steam is equal to a constant times the absolute initial pressure. The equation representing this relation is:

$$W = 0.86 A p_1 \dots\dots\dots (26)$$

where W is the amount of steam flowing through the orifice in pounds per minute.

A is the area of the orifice in square inches.

$p_1$  is the absolute pressure in front of the disc, pounds per square inch. For a given orifice equation 26 takes the form of

$$W = C p_1 \dots\dots\dots (27)$$

where C is equal to  $0.86 A$  and represents pounds of steam per minute per pound absolute initial pressure. The following table gives the value of C for orifices from  $\frac{1}{8}$  in. to  $1\frac{1}{2}$  in. diameter.

Orifice .....	$\frac{1}{8}$	$\frac{17}{32}$	$\frac{9}{16}$	$\frac{19}{32}$	$\frac{3}{4}$
Value of C.....	0.1685	0.193	0.214	0.238	0.264
Orifice .....	$\frac{21}{32}$	$\frac{11}{16}$	$\frac{23}{32}$	$\frac{3}{4}$	$\frac{25}{32}$
Value of C.....	0.291	0.319	0.349	0.380	0.412
Orifice .....	$\frac{13}{16}$	$\frac{27}{32}$	$\frac{7}{8}$	$\frac{29}{32}$	$\frac{15}{16}$
Value of C.....	0.446	0.481	0.517	0.554	0.593
Orifice .....	$\frac{31}{32}$	1"	$1\frac{1}{16}$	$1\frac{1}{8}$	$1\frac{3}{16}$
Value of C.....	0.633	0.675	0.763	0.855	0.951
Orifice .....	$1\frac{1}{8}$	$1\frac{5}{16}$	$1\frac{3}{8}$	$1\frac{7}{16}$	$1\frac{1}{2}$
Value of C.....	1.055	1.163	1.276	1.395	1.52

Thus it is a very simple matter, when live steam is used, to measure and regulate the amount supplied to the generator. With a boiler pressure of 100 lbs. gauge, the pressure in front of the disc can be varied from 80 lbs. to 40 lbs. and still have less than  $\frac{3}{8}$  of the absolute pressure immediately after the disc; so that for a given initial pressure the supply to the generator will always be constant irrespective of any change produced in the back pressure within the given limit.

In some places, where live steam is used, the up and down reversing valve is made to be also the steam admission valve for the run. The main steam valve on the line is kept open, being regulated to show the desired pressure on the disc, and this valve does not have to be changed unless there is a large variation in the boiler pressure, or a change is desired in the supply of steam. The advantage of this arrangement is that the admission valve is opened with a single movement and no time is spent on the adjusting of the steam flow.

*Operating with Exhaust Steam.*

From our point of view, however, the use of live steam for the gas generator will soon become a matter of the past. The success they have met in Chicago with the adoption of the superheated exhaust system will necessarily be duplicated with still higher economy in places where boiler fuel is more expensive than in Chicago. Numerous comparative tests between live steam and superheated exhaust for the generator have shown decidedly that in the latter case the saving in boiler fuel was about equal to the amount that would be required to generate 30 lbs. of steam per M cu. ft. of gas produced, while the amount of fuel consumed by the superheater is very little. (See PROCEEDINGS of the American Gas Institute for 1913, Part 1, pp. 358-366, on the use of exhaust steam in water gas generators.)

The measurement and regulation of the exhaust steam supply to the generator, a problem that was being experimented on for the last 2 years, has met with a fair degree of success at present. The methods that have been employed so far will be discussed briefly for comparison, as some of them may be more successful in one place than in another.

*The Disc Orifice for a Low Differential Pressure.*

At first a disc was inserted in the exhaust steam line, similar to the one used on live steam but with a comparatively much larger orifice. A mercury monometer to which the 2 sides of the disc were connected indicated the drop of pressure through the orifice. The steam admission valve was manip-

ulated to keep the mercury column at a constant height, thereby insuring a uniform flow of steam into the machine.

When the ratio between the pressures in front and in back of the disc is less than  $\frac{2}{3}$ , the amount of steam flowing through the orifice can be figured from the equation.

$$W = 1.7 A \sqrt{p_1(p_1 - p_2)} \dots\dots\dots (28)$$

where  $w$  is the flow through the orifice in pounds per minute.

$A$  is the area of the orifice in square inches.

$p_1$  is the initial pressure, pounds per square inch absolute

$p_2$  is the final pressure pounds per square inch absolute.

For the conditions of exhaust steam  $p_2$  can be considered nearly constant with an approximate value of 16 lbs. absolute. If  $H_m$  is the height of the mercury column, in inches, balancing the drop of pressure through the orifice, then  $p_1 - p_2 = 0.49 H_m$ , and equation 28 is changed to the form of:

$$W = 4.82 A \sqrt{H_m} \dots\dots\dots (29)$$

with the notations as above.

The main objection to this method is the additional back pressure on the machinery of the plant caused by the drop of pressure through the orifice. To make the results fairly accurate a differential of at least 2 in. of mercury would be required, which means 1 extra pound of back pressure on the exhaust steam line at all times.

#### *Regulating the Steam Supply by the Drop of Pressure Through the Machine.*

In one instance where the exhaust steam to the generators was being gauged by opening the admission valve to a given mark, the change from this to running by a differential gauge indicating the drop of pressure through the machine, had shown a decided improvement in the results of the operation. At first it was desired to illustrate the changes produced in generator pressures, and the variation of the flow when several machines are being operated on the same line. For the purpose of comparison, pressure readings were taken of the various compartments of a machine, first, when running by itself,

then 2 successive runs with 4 machines in operation. Of the last 2 runs, in the first run the 4 machines were started at intervals of 1 minute, one after another; in the second run all 4 machines were started simultaneously.

When these pressures were plotted against the time, (see Figs. 19 and 20) it was noticed that in either case the uniform operation, or the run when no change was made in the number of machines running, is marked by a uniform drop

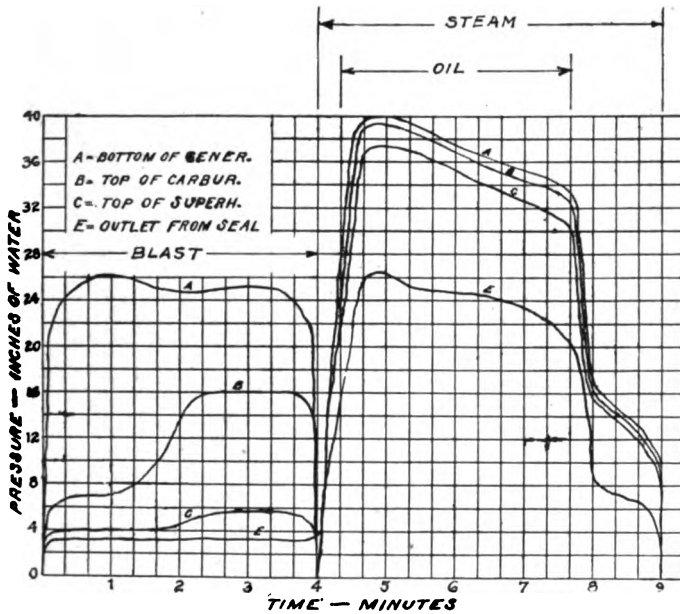


Fig. 19.—Run with superheated exhaust steam, 1 machine in operation.

of pressure between the different compartments of the machine. From this it was inferred that if a uniform drop of pressure were kept between 2 compartments of the machine it would result in a uniform operation irrespective of the changes in the number of machines running.

Accordingly, a differential water gauge was connected between the bottom of the generator and the inlet to the seal on each machine, and the gas makers were instructed to regu-

late the steam admission valve so as to maintain a given differential pressure during the run. It was found after, that the

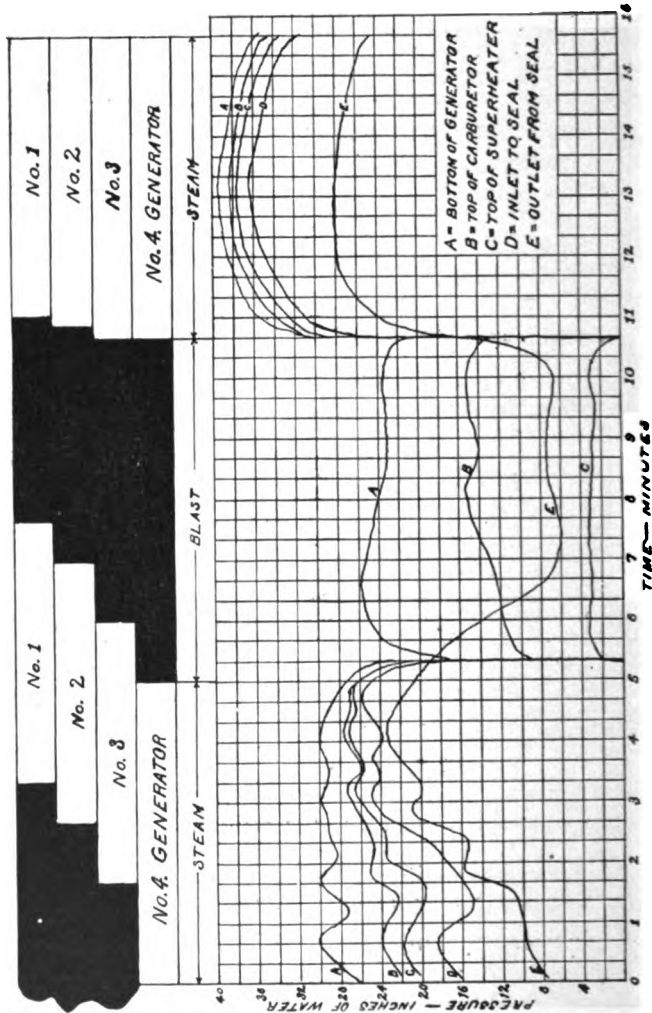


Fig. 20.—Two runs with superheated exhaust steam, 4 machines in operation.

only time the steam valve required adjustment was when an other machine went on or off the run, as it could be expected.

It is understood that with this method of regulation nothing can be obtained in the way of measuring the steam supplied to the generator. In general the method can be used with a great deal of discretion only as an index to readjust the flow when another machine is coming off or on the run. All that can be said about the method is that it is more efficient than running by the valve opening to a given mark, or by maintaining a constant pressure at the bottom of the generator. After the pitot tube device (given in the following chapter,) was introduced as a means to measure and regulate the steam flow to the generator, this differential gauge was also retained to indicate the pressure drop through the machine for a given flow of steam. By this means it can be found out when a machine is blocked up by an abnormal resistance and has to be cleaned or rechecked.

*The Pitot Tubes and Differential Gauge as a  
Steam Meter.*

For the last 2 years experiments were carried on with various forms of pitot tubes in the endeavor to design a meter suitable for the measurement of exhaust steam to the generators. The pitot tube as a steam meter had been used by the trade successfully for a number of years. However, none of the instruments on the market could be applied to our lines which were placed under the operating floor, because all meters are so designed that they cannot be operated when placed at a higher level than the steam line. It was necessary, therefore, to work out an arrangement of transmitting the vapor pressure to the differential gauge directly, as if it were for air or gas. After a number of failures, the following arrangement had proved very successful, and had been passed upon as the best method for measuring and regulating the amount of exhaust steam supplied to the generator.

Referring to Fig 21, the pitot tubes inserted in the steam line are of the same multi-opening type as those of Fig. 16, used for air or gas measurement. The tubes are inserted from the top of the pipe, and in the plugged end of each tube

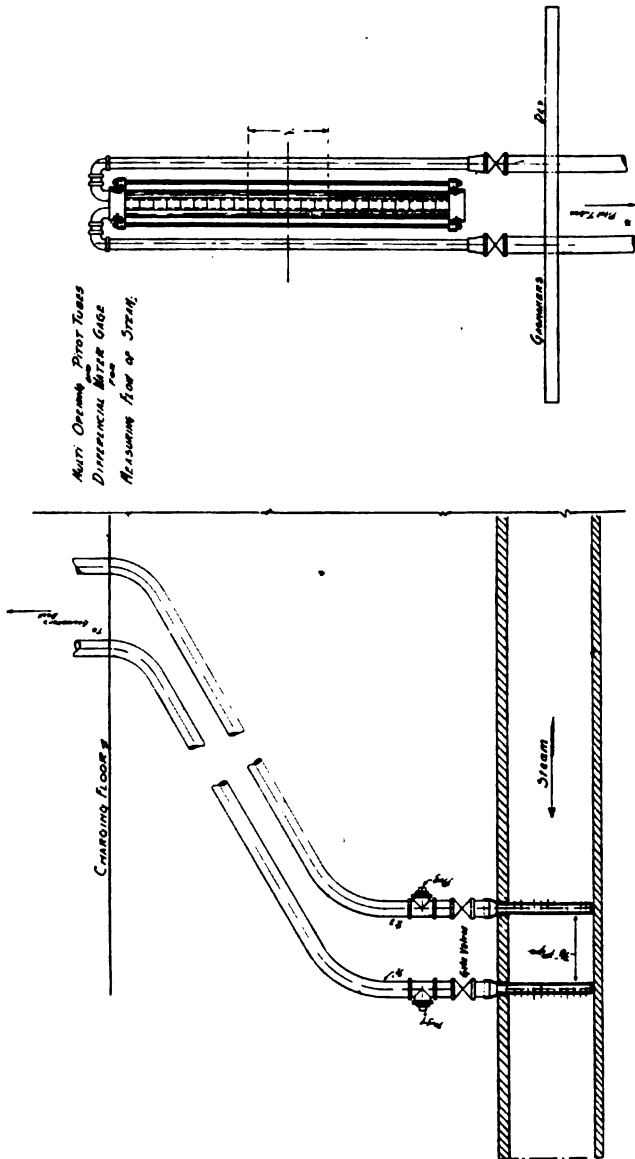


Fig. 21.

a small opening is provided for draining the condensation back into the line.

From the tubes,  $\frac{1}{2}$  in. pipe leads, with large radius bends, are carried on an incline to a differential water gauge placed against the gas maker's desk. Care must be taken that the gauge glass and fittings should be perfectly tight in order to trap the cold air in the pipes and to prevent the condensation from filling up the gauge glasses.

The impact of the flow upon the openings of the front tube, combined with the syphoning produced upon the openings of the back tube, result in the differential column  $h$  shown on the gauge glass. Applying equation 9, which is general for all fluids, we have—

$$V = 1.098C\sqrt{\frac{h}{\gamma}} \dots\dots\dots (30)$$

and

$$G = VA\gamma = 1.098CA\sqrt{h\gamma} \dots\dots\dots (31)$$

where  $V$ , is the velocity of the steam in feet per minute;

$h$ , is the height of the water column in inches;

$\gamma$ , is the density of the steam in pounds per cubic foot;

$G$ , is the weight of the steam flowing through the pipe in pounds per minute;

$A$ , is the area of the pipe in square feet,

and  $C$ , is the coefficient of the tubes.

For a pipe of diameter  $D$  in inches.

$$G = \frac{1.098 \times 0.7854}{144} CD^2\sqrt{h\gamma} = 5.99CD^2\sqrt{h\gamma} \quad (32)$$

The coefficient of the tubes is approximately 0.75, and for a given diameter of pipe, say 8 in.

$$G = 5.99 \times 64 \times 0.75\sqrt{h\gamma} = 287\sqrt{h\gamma} \dots\dots\dots (33)$$

The value of  $\gamma$  or the density of the steam at the given pressure and superheat can be taken from steam tables. For a pressure of 3 lbs. gauge and 400° F. temperature of the



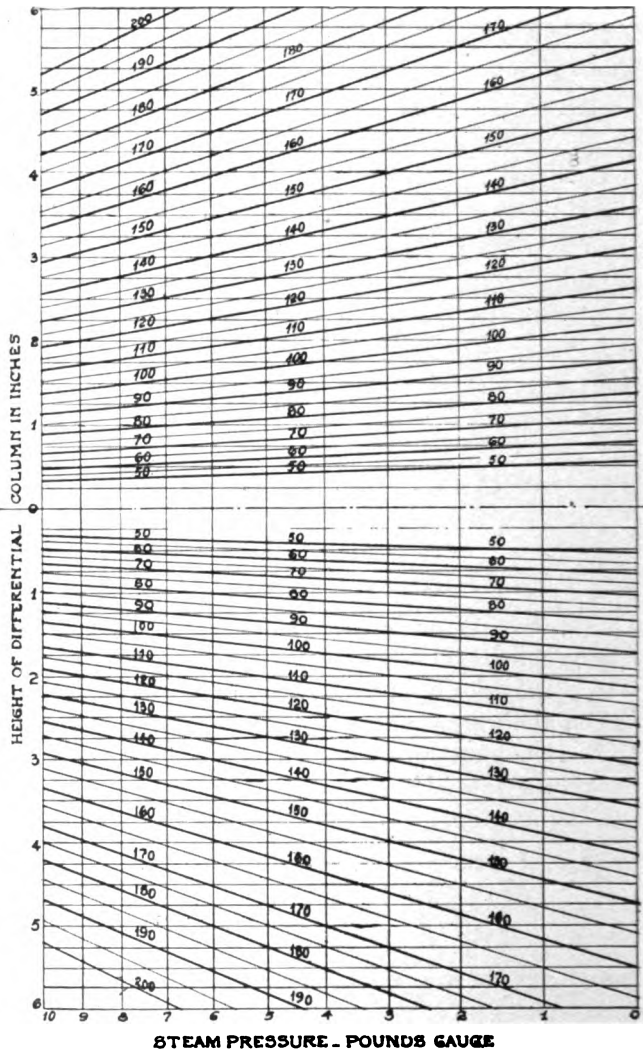


Fig. 22.—Chart for 8-in. pipe. Read pounds per minute. For U-tube. Steam superheated to 400 degrees F.

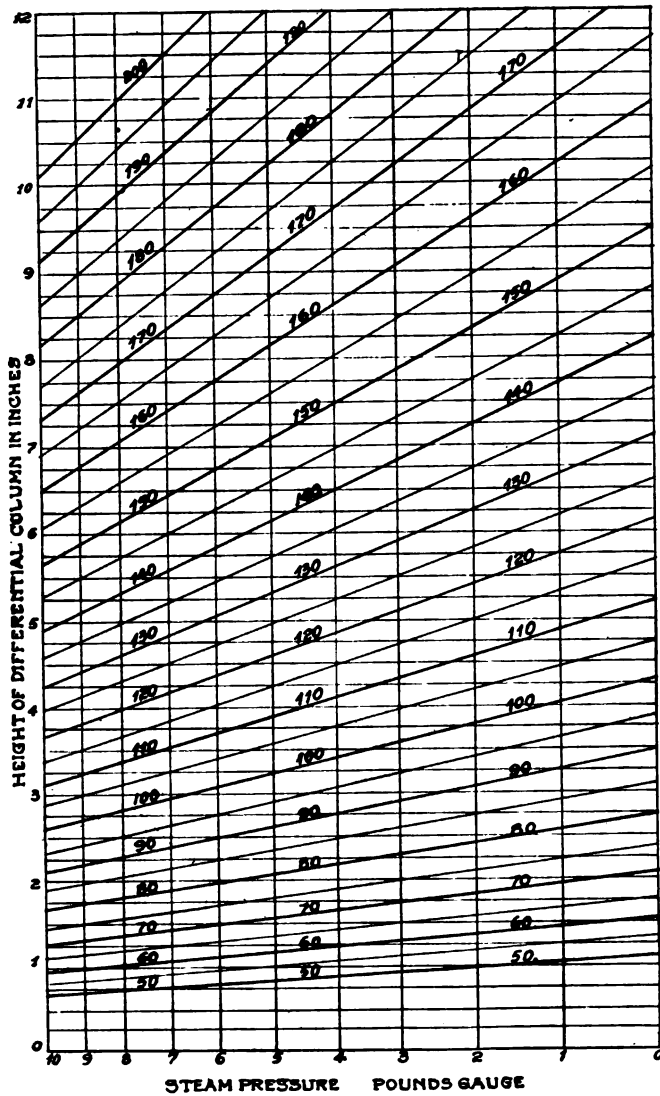


Fig. 23.—Chart for 8-in. pipe. Read pounds per minute. For single tube. Steam superheated to 400 degrees F.

steam,  $\gamma$  is equal to 0.0347 and equation 33 is reduced to the form of—

$$G = 53.51/\bar{h} \dots\dots\dots(34)$$

Fig. 22 shows a diagrammatic scale, or chart, designed according to equation 33, for a U-tube differential gauge indicating the flow in an 8 in. steam pipe for pressures of the steam between zero and 10 lbs. gauge. For a small variation of pressure the proper section of the diagram is attached to the scale between the glasses, and instead of inches of water, pounds of steam per minute are read directly from the differential water column.

Fig. 23 shows the same chart designed for a single column differential gauge which is more convenient for indicating the amount of flow, though, on account of the variation in the zero level, it is not as accurate as the U-tube gauge. For any other size of steam pipe, the kind of chart desired can be made up in a similar manner.

In conclusion it may be stated that while the Pitot tube in general is an instrument that is subject to local irregularities requiring calibration for each given case, it is the ideal guide for regulating the air blast and the steam supply to the water gas generator.

The writer wishes to acknowledge his indebtedness to Mr. R. N. Davis and Mr. C. E. Reinicker for valuable suggestions and information on the subject, and to Mr. S. A. Reinhardt for efficient help in performing the experiments connected with this work

(Mr. Spitzglass read an abstract of his paper.)

THE ACTING CHAIRMAN: We have a written discussion from Mr. Moss which the Secretary will read.

MR. S. A. MOSS (Lynn, Mass.): (Written discussion communicated.) It must be understood that the general formulas given for pressure produced by centrifugal force in a blower, etc., apply more particularly to the ordinary fan blower, and are only roughly true for the more refined apparatus for pro-

ducing higher pressures, called the "centrifugal compressor." In these machines, used mostly for high pressures, the compression of the air is an important item, and compression action must be secured. This effect is not large for the pressures used in water gas work. Nevertheless, centrifugal compressors for such work, designed on the same basis as centrifugal compressors for higher pressures, give higher efficiencies than possible with the common fan blowers.

Mr. Spitzglass gives a number of characteristic curves for different types of blowers. It must be emphasized that each such curve is for constant speed, and in order to secure it, there must be some type of governor. That is to say, the characteristic curves which are given are not inherent characteristics of a blower itself, but are characteristics of a complete machine, including a turbine governor or electric motor winding, so arranged that the speed of the shaft is constant. In the case of turbine drive it is easy to arrange for a governor not controlled by the speed of the shaft, but controlled by the volume of air being delivered, of the pressure of air being delivered, or by the volume of primary air, etc. Similar results not giving so much flexibility, however, can be secured by arrangement of the motor field windings, such as by the use of series windings instead of shunt windings, etc. In other words, the constant speed characteristic, which seems to be assumed as the primary characteristic of all blowers is not at all inherent. Hence, instead of having a constant speed governor and then arranging the impeller angles and vanes so as to give a characteristic to suit the water gas generator, the governor can be arranged to operate so as to directly give constant pressure or constant volume. Without taking the space for detailed description, it can be stated that a complete system of governing can be very easily applied to water gas work so as to give any desired characteristic. This wholly omits the use of a speed governor to give the constant speed characteristics to be afterwards corrected. The system involves the use of single centrifugal compressor for delivering both primary

and secondary air, with governing systems to give desired characteristics of each flow independently. The arrangement may be to give constant rate of flow of primary air with provision for hand regulation of secondary air, or there may be independent governors so as to give constant rate of flow of both primary and secondary air, or there may be governors to give constant rate of flow of primary air and increasing rate of flow of secondary air, according to any predetermined characteristic.

It is to be remarked that Mr. Spitzglass' idea of trying to compromise a blower characteristic so as to roughly suit the water gas generator requirements, and then trying to arrange the actual operation of the blower so that it works at the right point on the characteristic curve, involves very serious difficulties.

As one of the specifications of a blower, Mr. Spitzglass gives the revolutions per minute. This is really not an essential item, for the reasons above mentioned, with a blower which has a proper governing arrangement.

Mr. Spitzglass also gives as specifications for a steam driven blower both the mechanical efficiency of the blower and the steam consumption of the turbine per brake horse-power. The buyer of a blower is really interested in the over-all performance, such as shown by the steam consumption in pounds for a specified air delivery, and is not particularly interested in the independent performance of the blower and turbine. Hence, the buyer need not go to the trouble of making specifications and tests except for the over-all efficiency.

Mr. Spitzglass very properly gives considerable space to the importance of determining the exact values for the rated pressure and volume of the blower. Many cases can be cited where blowers have been selected for water gas generators with rated volumes, which turn out to be greatly different from the volumes actually used when machines were installed. It is, of course, highly desirable to avoid such discrepancies.

Mr. Spitzglass devotes considerable space to measurement

of air flowing at low velocity in a pipe. It is, of course, well known that such measurements are exceedingly difficult. The differential pressure shown by the Pitot tube is an exceedingly small quantity, and it is very difficult to compute the total volume from it, particularly when the velocity varies in different parts of the pipe, as is mentioned. A much more satisfactory plan is to test the blower independently of its operation on the gas generator, and waste the air by discharging it through a measuring orifice. Then the full discharge pressure of the blower can be used as pressure on the measuring orifice, giving a quantity which is very easy to observe accurately. In other words, measurement of air flowing in pipes should be avoided whenever possible.

MR. J. H. TAUSSIG (Philadelphia): I should like to say that Mr. Spitzglass deserves a great deal of credit for his clear paper on blowers and the measurement of air and steam. I think one need only to glance at the paper to see the great amount of work he must have done in this line. He has opened up a subject in the regulation of blowers and the keeping of conditions on a water gas generator,—at least, he has dealt in a subject that we are very much interested in, and I think a careful study of this paper will do us all a great deal of good.

MR. J. A. PERRY (Philadelphia): I do not believe a blower should be bought without specifications, and accepted, without a test to see that the specifications are lived up to. I think it was suggested here that we have standard specifications for testing blowers, and I think that ought to be referred for further action during the coming year, so that we may have those standard specifications for testing before we accept the blowers.

THE ACTING CHAIRMAN: Do you wish to make a motion that a recommendation be made to the incoming Technical Committee to that effect?

MR. PERRY: Yes, sir.

MR. ROLLIN NORRIS (Philadelphia): I second the motion.

MR. G. I. VINCENT (Des Moines): I think we ought to add

to that the standardization of the Pitot tube. If it is true, as has been explained in Mr. Spitzglass' paper, that the American Blower Company, and the Empire and Taylor and other tubes do not have a constant co-efficient, I think we should find out something a little more definite than we know now. Mr. Spitzglass' development of the theory of the Pitot tube is certainly better than I have ever seen. It is very clear and very concise, and covers the subject thoroughly. Mr. Spitzglass' statement that he had succeeded in developing a Pitot tube that did have a constant coefficient seems to be very interesting indeed, and ought to be taken up further by this organization; so, with the permission of the maker of the motion, I should like to add to the motion, if it is in order, that the standardization of the Pitot tube be included in the other work.

THE ACTING CHAIRMAN: It is. The motion is made that the standardization of the Pitot tube be included, and I understand the maker of the first motion accepts the amendment. It has been moved and seconded that a recommendation be sent to the incoming Technical Committee for the preparation of standard methods of testing blowers, and that the standardization of the Pitot tube be taken up this coming year if possible. All those in favor of that motion, answer in the usual manner. (Ayes.) Opposed. (No response.) It is carried. We have a written discussion from Mr. Hunter, which the Secretary will read.

MR. J. F. HUNTER (New York): (Written discussion communicated.) I think Mr. Spitzglass should have the thanks of the members of the Institute for his excellent paper, calling attention to a very important, but frequently neglected, element in the making of water gas.

In commenting on this paper, I propose to pass over the theoretical discussion, except that I desire to call attention to the fact that in determining the weight of air moved, Mr. Spitzglass has not included the necessary correction for humidity. This correction would not materially affect the results and

could be omitted in a test made under the conditions described in his paper.

In describing the method to be used for determining the capacity required for the fan, Mr. Spitzglass uses as the basis of his calculations, the make per square foot of grate per hour "of actual operation (blowing, gas making and charging)." This does not take account of the time lost in cleaning the generators, and gives a figure that cannot be used in comparison with the results obtained in other plants unless the cleaning time is known. It is our practice to divide the total make per square foot of grate per day by 24 to determine this factor, and the figure obtained is directly comparable without further modification. When the make is stated in this way, in order to produce Mr. Spitzglass' figures, it will be necessary to multiply it by the fraction  $\frac{24}{X}$ , where X equals the hours of actual operation.

Passing on to the practical considerations, I cannot agree with Mr. Spitzglass that the acceptance test for blowers should be made in actual service. From a commercial standpoint, I believe the fan builders would be unwilling to delay the acceptance and final payment for their apparatus until such a test is possible, as in many cases, particularly in extensions or new plants, the blowers are delivered and installed weeks before the generators are ready to operate.

When the water gas machines are equipped with individual blowers, the blowers are located as close to the generators as possible. The blast pipes, particularly the larger sizes, are usually made up with riveted lap joints, which, with the bends and outlets, introduce eddy currents and friction losses. As Mr. Spitzglass points out, the resistance of the fire bed is constantly changing, and as the period of operation is short, I feel that under service conditions, a test for acceptance, which would be satisfactory to the builder and to the purchaser, is practically impossible in the majority of plants.

I believe a better way would be to specify that the fan



builder shall assemble the complete unit and run a test at the factory in the presence of a representative of the purchaser and of the builder of the engine or motor. The characteristic curve of the fan should be plotted and submitted with the report. A test made under these conditions permits the accurate determination of the power input of the driving mechanism, as the conditions can be controlled and held constant for any desired period. With the complete data in regard to the fan and driving mechanism previously determined, the point on the characteristic curve at which the fan operates can readily be ascertained after installation, with sufficient accuracy for all practical purposes; and adjustments of this location can then be made by altering the speed.

When the test is to be made at the factory, the method to be used should be stated in the specifications. The most conservative method, that is, in favor of the buyer, is known as the Navy or Taylor method, and is made practically as described by Mr. Spitzglass, using the Taylor Pitot tube. This method requires the location of the Pitot tube to be not less than 20 diameters of the pipe from the fan. The pressure in the discharge pipe is controlled by a valve at the end.

Another method which is frequently used is that in which the air is discharged into the atmosphere through a converging nozzle attached directly to the fan outlet. The Pitot tube is placed at the orifice, at which point all of the energy is transformed into velocity. The pressure against which the fan operates is controlled by varying the size of the orifice. The proper corrections must be made for the varying co-efficients of discharge for converging nozzles.

THE ACTING CHAIRMAN: Is there any additional discussion on this paper? (No response.) Mr. Spitzglass, will you close?

MR. SPITZGLASS: We will take up the discussion by Mr. Moss. He discussed the paper, of course, from the manufacturers' point of view, and it is very encouraging, for the purpose of the paper, which was mainly to bring about a better understanding between the maker and the user of the centrif-

ugal blower. Indeed, I was very glad to see Mr. Moss send in a discussion, showing that it already appealed to one of the manufacturers.

Regarding his first point, about the general formula applying more particularly to the fan blower, I would say that the opposite is true. Since the "refined apparatus" transmits more velocity energy into pressure, the results should correspond closer with the general formula. Unless Mr. Moss is of the old school that were trying to prove that the theoretical head of the centrifugal blower is only one-half of  $\frac{V^2}{g}$ . That point was argued for a long time,—whether the theoretical head of the centrifugal blower is  $\frac{V^2}{g}$  or  $\frac{V^2}{2g}$ . After the explanation I have given in the first chapters of the paper, concerning the pressure energy and velocity energy, there should be no misunderstanding in the applications of the general formula.

His second point,—about the characteristic curves,—that they are only for constant speed, is correct, and that is what I have repeated many times in the paper. But those characteristics certainly are inherent to the blower as far as the relation of the pressure and the volume is concerned, while the speed is only a condition which is taken care of by the speed regulator.

Mr. Moss advises the use of a constant volume regulator instead of a constant speed regulator. The question is, however, whether we want a constant volume for blasting the gas machine. To my opinion, a constant volume is not economical because you can not utilize your blower and the whole apparatus to the full advantage. Mr. Moss states that my idea of compromising characteristics to suit the requirements of the operation involves "very serious difficulties." Well, we have been running without any compromising for many years, and we never ran into any "very serious difficulties," so that there is no danger in that. (Laughter.) Mr. Moss remarks that the speed of a blower is not essential. Well, I said that the speed is usually given by the manufacturer, then you can

check it yourself. It is not very essential, if you let him do it. (Laughter.) But, at the same time, the manufacturer should be held responsible upon a certain speed, to have the pressure and the volume specified at that speed. At times, on testing the blower, the pressure or the volume is not up to specifications. "Speed it up a little." Yes, speed it up,—you need some power to do that. (Laughter.)

Regarding the efficiency, Mr. Moss mentions that it should be over-all efficiency. I have said that in the paper,—I said that in order to be of any value, the efficiency should include the drive also, but I have given it in general terms. The efficiency should be the air horse-power divided by the steam horse-power, then you know what it is. Mr. Moss advises that we should make the efficiency read so many cubic feet of air for so many pounds of steam. But how could you compare one case with another, where the pressure is different, and consequently the cubic foot is different. How would you know in general whether so many cubic feet for so many pounds of steam is high or low efficiency, unless you would resort to dividing the output by the input in the same general unit. To specify cubic feet of air per pound of steam would be the same as to sell grain for cattle, as they used to do in olden times.

About the testing of the blower, if it is understood that I meant the testing should be done after the blower is all connected and operating on the generator, then I will take it back. I did not mean that. I meant the blower should be tested in a way that can be checked during the actual operation. If during the operation you see that the amount of air is diminished, you know that either the resistance of the machine is increased or the speed of the blower is diminished, and you act accordingly.

Mr. Hunter brought up the question of humidity. I explained that the humidity does not enter into the figuring. The amount of moisture contained in the air at the inlet to the blower will remain materially the same in the discharge

from the blower. If the figuring should be done on the basis of dry air, the correction on the inlet air would credit the blower for the partial pressure of the moisture, and the correction on the discharge would debit the blower for the same quantity. Since the absolute amount of moisture present in the air does not change by going through the blower, the two corrections balance each other and do not have to be considered.

About the make per square foot, I would say that the object of the paper is, as I said, "Methods and Facilities." I did not mean the given data to represent good or bad practice. I took it at random, merely to illustrate the case.

About the method of measuring the volume of air, I have given enough reasons in the paper for selecting the Pitot tube. Those reasons were even sufficient to overbalance the uncertainties about the accurate application of the Pitot tube as it was generally known at that time. Since I have written the paper, I have succeeded in working out an equal-area Pitot tube of a very practical form, and which, according to the tests I have made recently, shows more accurate results than anything that has been used before. With that tube, it is not necessary to go to the trouble of traversing the pipe for the different velocities, and it is so constructed that it does away with all the uncertainties in the applications of the other Pitot tubes. Here I have a diagram (Fig. 1) showing the results of the tests I have made on this equal-area tube, and also on a Taylor tube, which is mentioned in the paper in connection with the test made by Mr. Rowse. The Taylor tube is supposed to have a co-efficient of 0.91 for the discharge, and as you will see from the curve, it is close to that co-efficient on the 16-in vertical pipe. On the 12-in. horizontal pipe, the co-efficient is quite different, due to the fact that in the horizontal pipe the center of the pipe may not have the maximum flow. This error does not come in my equal-area tube, and as you will see from the curves, the co-efficient of the equal-area tube is the same for both sizes, vertical and horizontal, and it runs

almost constant between 0.80 and 0.81 for all velocities. We will have a chance to dwell on this subject again in discussing the next paper on the measurement of gas in large volumes.

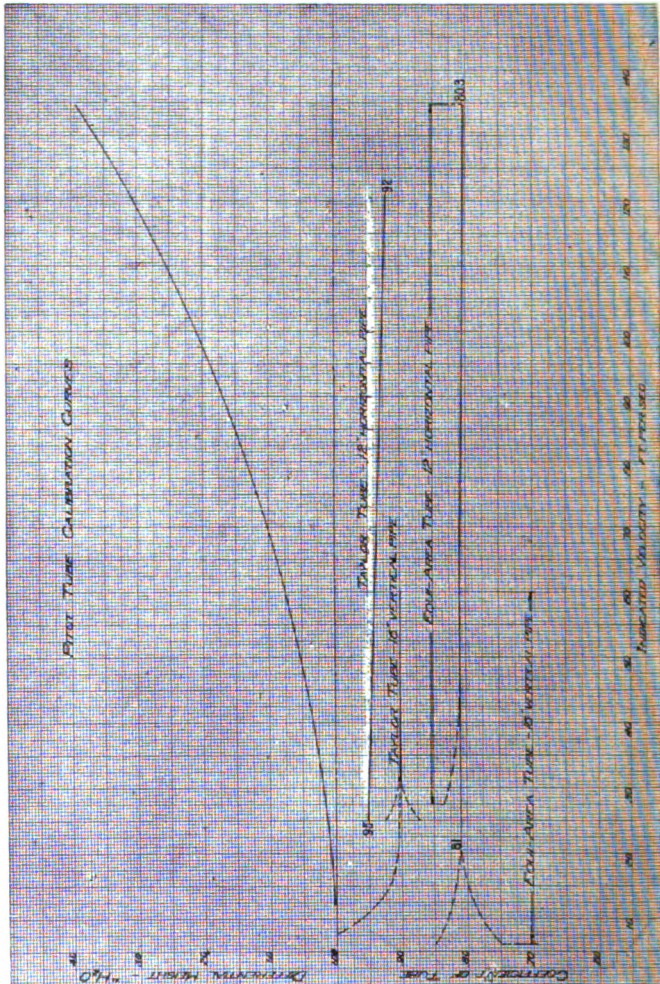


Fig. 1.

About the suggestion of standardizing the tube in connection with the method of testing blowers, I would say that if the case is taken up by a committee of the Institute, I believe

that our company will give the assistance necessary for advancing this work.

I thank you.

MR. G. T. MACBETH (Mount Vernon, N. Y.): I move that a vote of thanks be given to Mr. Spitzglass for his paper, expressing to him our appreciation of the very hard work and very close detail exhibited, and the very fine way in which he has arranged it so that we can test our blowers in the future.

The motion was seconded and carried.

THE ACTING CHAIRMAN: The next on the program is the Report of the Committee on Measurement of Gas in Large Volumes, by Dr. J. F. Wing, Chairman, of Everett, Mass.

## REPORT OF THE COMMITTEE ON MEASUREMENT OF GAS IN LARGE VOLUMES.

The art of measuring gas commercially is an important one, whether it is done in large or small quantities.

When it is done in large quantities, the importance and difficulties are centered in a few large units, which are more generally used as a measure of efficiency in manufacture than to measure the volume bought or sold. In any case, the value of the commodity measured is so much more than that of free air or natural gas, that this property justifies careful oversight. And, in general, measuring implies the utmost practical accuracy.

The measurement of this invisible product has always been a subject of obscurity and doubt to different classes in the community, and often of not much less doubt to the gas man than to the layman.

The only meter we have, in the measurements of which we can always really believe our eyes, is the gas holder. All the other methods take place in closed vessels, handling an invisible fluid, and count by an external indicator. The meters have moving parts likely to get out of order, or surfaces that may become clogged, or are indicated by delicate measurements, and all have the possibilities of indicating incorrectly

and must be controlled by periodic tests to insure their continued accuracy.

In this report, "large volumes" is a relative term as understood by each gas company.

The different methods of measurement come under two classes:

I. Direct or Positive Methods, in which the gas displaces a known volume in a moving apparatus, which can register the motion.

The methods comprise:

Gas holders.

Wet drum meters.

Diaphragm meters and

Calibrated exhausters.

II. Inferential Methods, in which the total quantity of gas is not actually measured but is subjected to various conditions and the amount is inferred from some effect of heat, pressure or impulse.

These methods comprise:

Velocity meters, such as the Venturi meter, the Pitot tube, calibrated orifices, anemometers, rotary meters and estimating the flow in pipes.

Proportional or shunt meters, in which a fraction of the total volume is measured by direct methods.

Calorimetric meters, such as the electric type meter, in which the volume is ascertained by the electrically measured heat required to raise its temperature.

It is proposed to discuss these devices from the points of view of practicability and reliability.

All can be set up, calibrated carefully and then will measure with commercial accuracy under the same conditions for a longer or shorter time. If subjected to changed conditions without their being realized and without compensating calibration, there are different degrees of reliability. The question of duplication of results is the most serious one, for several are built from designs of successful ones and then are

used without preliminary comparison with a positive measuring standard, and often under different conditions from the standard one.

No builder of a wet station meter would presume to guarantee its accuracy, even if built with the closest possible imitation of another, without testing it for registration as well as for leaks.

#### GAS HOLDERS.

Little need be said about large gas holders. Under favorable conditions of sunlight and temperature they are accurate. But when these conditions are not favorable, they are suitable only for a rough measurement of gas as manufactured or when transferred. They are seldom practicable.

The small calibrated gas holder is the standard by which all measuring devices are finally tested.

#### WET DRUM STATION METERS.

For measuring large volumes of gas, the station meter is the most accurate and reliable instrument which we have. As a secondary standard, all other devices are referred to it. It has been classed "among the most beautiful of mechanical inventions, simple and automatic in operation while assuring the absolute correctness of the work it is designed to do."

Its accuracy does not depend on the constancy of many factors entering into its operation. It measures positively, by displacement, gas of any gravity, and, within wide limits, of any temperature or pressure. It will do this when very dirty indeed.

Usually station meters do not have their fair share of attention. It is very difficult to oil the main shaft properly. The index and gears must be oiled with good light oil occasionally and the stuffing box of the secondary shaft refilled with greased wicking. It is well to have all noises diagnosed by a competent man.

After an uncertain length of service, some moving parts may give out, and the comparatively light drum will be corroded by oxygen in the gas, or that contained in the fresh



water dribbled in to hold the water level, or by the casual presence of ammonia or sulphuretted hydrogen in the gas. It may be badly corroded and still measure correctly, then soon afterward become perforated in hundreds of places by the strain of hard running or of starting up. Bolts and rivets may work loose or even fall out. The leaking condition may be discovered by a standstill test on each compartment of the drum.

The following are careful tests on the three 16 ft. Hinman drum station meters, 15 years old, of a large gas company, taken 3 and 5 years after being overhauled. The tests were carried out because they were suspected of not registering correctly.

**Three years after overhauling:**

No. 1—1% fast      No. 2— $\frac{1}{3}$ % fast      No. 3— $\frac{6}{100}$ % slow

**Five years after overhauling:**

No. 1— $\frac{1}{2}$ % fast      No. 2— $\frac{4}{10}$ % slow      No. 3— $\frac{1}{3}$ % slow

These, certainly, were as accurate as could be hoped. But it is sensible to be not wholly confident of such an obscure apparatus. Before being overhauled, they were in very bad condition.

In other respects, wet meters are unsatisfactory. They are costly, cumbersome, heavy, and require a large space for installation; a 16 ft. meter weighs over 100 tons with its water and necessitates particular care in a foundation 16 ft. square. They are not flexible like a boiler for overloads. A 16 ft. meter rated at 4,000 M per day passes 6,000 M at considerable risk. As a protest against all this, much thought and ingenuity has been exercised to devise some more convenient apparatus, and with considerable success.

This report will not deal with the construction, operation and testing of meters. These topics have been treated very ably in a paper by Mr. Donald McDonald presented to the Congress of American Gas Association in 1904. This pamphlet of 40 pages was undertaken with the object "to supply an apparent lack, in the records of the Association, of

information on the subject of the station meter." It is a store of information for all concerned with meters.

If the wet station meter were the main subject of this report, it would contain a reprint of the detailed directions of the Trustees of the Educational Fund, in the 1907 Report of the Gas Institute, in answer to the question, "Describe the testing or proving of a station meter, giving each step of the work from putting it out of use, in order to test it, to putting it to work again after it has been tested."

We give a table of data of wet station meters:

#### DATA OF WET STATION METERS.

Donald McDonald, 1904—Proceedings of Gas Congress.

Size	Capacity per hour in cu. ft. with 1" loss		Usual size of con- nections	Weight of meter. Lbs.	Weight of water. Lbs.	Weight of meter and water. Lbs.
	Parkinson	Hinman				
4'	5,200	8,000	8"	3,800	2,200	6,000
4' 6"	6,800	11,250	8"	4,950	3,100	8,050
5'	8,500	14,500	8"	5,950	4,200	10,150
5' 6"	10,400	18,000	10"	7,450	5,650	13,100
6'	12,400	21,750	10"	8,750	7,350	16,100
6' 6"	14,700	25,750	12"	10,500	9,300	19,800
7'	17,100	30,000	12"	12,250	11,500	23,750
7' 6"	19,800	35,000	12"	14,350	14,000	28,350
8'	22,500	40,000	12"	16,600	17,250	33,850
9'	28,800	51,000	16"	24,000	24,500	48,500
10'	36,000	63,000	16"	29,500	33,500	63,000
11'	44,000	77,000	16"	36,000	44,200	80,200
12'	53,000	92,000	16"	44,500	57,500	102,000
13'	63,000	109,000	20"	54,000	73,300	127,300
14'	74,000	128,000	24"	66,000	91,500	157,500
15'	86,500	150,000	24"	80,000	112,500	192,500
16'	100,000	173,000	24"	95,000	136,000	231,000

#### DIAPHRAGM METERS.

Diaphragm meters do not have the capacity to measure the volumes we call large. They are positive displacement meters, but of a size suited for retail measurement. The nature of their construction does not permit them to be built very large. The biggest one, a 500 light meter, is not good for more than 5,500 ft. per hour.

#### CALIBRATED EXHAUSTERS.

Calibrated positive exhausters or blowers offer a direct

method for the approximate measurement of gas. They are built of sizes to comply with almost any demand for capacity.

They are displacement meters, because they propel a volume of gas with every revolution, but they lack the reliable accuracy of a station meter because the gas compartments are not water sealed and inevitably leak some gas by the contact surfaces back to the low pressure side.

A blower or exhauster that is in good condition and has been running long enough to acquire a coating inside is a better measurer than is generally supposed, if the temperature and pressure are taken into account, and if the difference of pressure increases as the square of the speed, then the leakage will be a constant percentage. If this last condition is not fulfilled, they leak more proportionally at slow speeds. An objection is that it is difficult to duplicate one by another.

If a blower is running well, it is more satisfactory and less liable to unsuspected derangement as a meter, than an inferential meter.

Considering the advantage of a counter and remembering the difficulties attending the reading of small pressure differences, a calibrated exhauster is quite as accurate as a calibrated Pitot or orifice meter. There is always some uncertainty as to the value of the efficiency of the last two.

#### VENTURI METERS.

There are many cases in the different industries where very large volumes of gas are required to be measured and positive wet meters are prohibited by the enormous volumes of gas and the expense, which is disproportional to the value of the gas and to the accuracy required. Such gases are air, natural gas, blast furnace and other fuel gases, which may be delivered as a commodity, or need to be controlled in some operation.

Also in the process of handling artificial gas it is sometimes desirable to know the amount in a case in which the expense or inconvenience forbids the installation of a station meter.

For these reasons much ingenuity has been exercised in developing reliable substitutes, called inferential meters.

One successful device is the Venturi meter. This is in the form of a contracted section of pipe laid in a pipe line, and is comparatively inexpensive and convenient to install.

The amount of gas passing it can be calculated by observing the pressures in the line and in the narrow part, called the throat, with the data of the areas of the meter and the condition and properties of the gas in question.

The throat of the Venturi meter causes decrease of pressure and increase of velocity. The general formula of the Venturi meter is derived on the assumption that the change of state in the gas between the entrance and throat of the meter takes place without gain or loss of heat. Therefore, the drop in potential energy as shown by the respective pressures is equal to the increase in the energy of motion indicated by the respective velocities at the entrance and at the throat.

While the Venturi meter is very accurate, if it is in good clean physical condition and located with a considerable length of straight approach and the pressure readings are taken very accurately, it is handicapped by having a very complicated formula for the expression of the volume of gas. The computation of results is very tedious and not simple.

This general formula is given for the sake of completeness:

$$Q = 210,840 A_2 \frac{T_2}{P_2} \sqrt{\frac{N}{(N-1)GT_1}} P_1 \left(\frac{P_2}{P_1}\right)^{\frac{1}{N}} \sqrt{\frac{1 - \left(\frac{P_2}{P_1}\right)^{\frac{N-1}{N}}}{1 - \left(\frac{A_2}{A_1}\right)^2 \left(\frac{P_2}{P_1}\right)^{\frac{2}{N}}}},$$

multiplied by an efficiency factor less than one.

In this:

$Q$  = cu. ft per hour on absolute pressure and temperature bases  $P_2$  and  $T_2$ .

$N$  = ratio of specific heats at constant pressure and constant volume.

$G$  = specific gravity of gas.

$A_1$  = area Venturi meter at entrance in square feet.

$A_2$  = area Venturi meter at throat in square feet.

$P_1$  = absolute pressure at entrance, pounds per square inch.

$P_2$  = absolute pressure at throat, pounds per square inch.

$T_1$  = absolute temperature at entrance, Fahrenheit.

For any particular meter and quality of gas and assuming definite values of  $P_s$ ,  $T_s$  and  $T_1$ , it reduces to a simpler form by having as the only variables the pressures. Then:

$$Q = KP_1 R^a \sqrt{\frac{1 - R^b}{1 - CR^{2a}}}. \quad \text{Wherein}$$

$$K = 210,840 A_1 \frac{T_s}{P_s} \sqrt{\frac{N}{(N-1)GT_1}}$$

$$C = \left(\frac{A_2}{A_1}\right)^2 \quad R = \frac{P_2}{P_1}$$

$$a = \frac{1}{N} \quad b = \frac{N-1}{N}$$

A direct reading chart furnished with the meter obviates this labor of computation.

For air or gas at or near one atmosphere of pressure desirable values of the ratio  $\frac{P_2}{P_1}$  are between the limits 0.95 and 0.995, corresponding to velocities of 300-100 feet per second, or a drop in pressure of 20 inches to 2 inches.

At higher pressure the velocity will be higher at the throat, but it is limited by the allowable drop in pressure, that is, the range of pressure permitted in the system.

The limiting value of the lower velocity depends on the least manometer reading of sufficient accuracy.

An approximate formula for a Venturi passing steam, with a discharge pressure less than 0.6 of the initial pressure, is the same as that for a nozzle:

$$\text{Lbs. per minute} = \frac{\text{Absolute initial pressure} \times \text{area in inches}}{1.16}$$

In respect to size, meters for gas are built for blast furnace use to be placed in a 60 in. line with 28 in. throat, and would measure up to 3,000,000 cu. ft. per hour with a differential of about 20 in. of water. This is not necessarily the limiting size.

Much information on this meter is given in a paper by E. P. Coleman, *Jour. Am. Soc. Mech. Eng.*, 1906.

There is a notice of a patent by R. Kennedy in the *Journal of Gas Lighting* for 1913, for putting a secondary inferential meter on the by-pass between the inlet and throat, instead of using an integrating device.

#### TESTS OF VENTURI METERS IN USE ON GAS.

From our correspondents, we have received reports of experiences that are not unanimous in the satisfaction expressed.

One reporter described a Venturi meter which collected deposits of naphthalene at the entrance, in the throat and after the throat and stopped up the pressure holes. This deposition was then prevented entirely by steam-jacketing. From this arrangement or some other cause, the measurement was very far out, and it was replaced by an electric meter, which, curiously enough, is not troubled by naphthalene, although some deposit has been noted in the entering pipe; and it measures consistently.

Measurements are reported by another gas company in the case of a 10 in. x  $3\frac{1}{4}$  in. meter lately installed to measure fuel gas. The registering device is calibrated to the total gas under standard conditions when the gas passing the meter is at 95 degrees, 9.6 in. water pressure and its sp. gr. is 0.49. When the conditions are different a correction factor is used.

The Venturi was on a line with a wet meter by which it was at first adjusted. This is not as severe a test as putting a meter in service as it comes calibrated from the makers.

The following were the metered results:

Time	Wet meter Cu. ft. free gas	Venturi meter Cu. ft. free gas
11:30 A. M. ....	000	000
12:00 .....	25,100	24,800
12:30 P. M. ....	52,200	52,000
1:00 .....	82,850	82,500
1:30 .....	112,700	112,500
2:00 .....	143,450	143,500
2:30 .....	174,900	174,800

A 12 in. x 6 in. Venturi has been connected to the station meter of the Providence Gas Company for a period of two

years. This one gives very satisfactory agreement. The registering gauge was calibrated for the average conditions of the water gas made. This meter is intended to measure a minimum of 30,000 cu. ft. per hour.

We have some data which show the comparison, and, also, the limitations:

Variations of Venturi on single days during four months:

1913	Max. fast Per cent.	Min. fast. Per cent.	Max. slow. Per cent.	Min. slow. Per cent.	For month. Per cent.
August.....	1.23	1.23	6.84	0.51	2.13 slow
September ....	1.66	0.79	3.78	0.40	1.54 slow
October .....	3.52	0.30	5.10	0.31	0.98 fast
November.....	3.17	0.41	0.52	0.20	1.66 fast

Average for four months.... 0.14 slow

NOTE:—Large errors are ascribed to shutting down and starting.

Careful comparative tests were made on April 13th and 14th, 1914, between the 14 ft. station meter and the Venturi which had a type Q. register, graduated in cu. ft. free gas at 30 in. and 60 deg., for 10 in. pressure and 0.675 sp. gr.

Both tests agreed closely on the average, but the data of the latter are given, since in that the rates of flow varied more.

The registrations of the meters are given, then the volumes corrected for pressure, temperature and specific gravity:

Time	Registration		Corrected		Venturi Per cent.	Venturi minute reading	Manom- eter	Loss of head
	Station meter	Venturi meter	Station meter	Venturi meter				
11 A. M.	62,000	64,000	62,750	63,750	+1.5	84,000	2.1"	0.3"
12	92,000	95,000	92,700	94,600	+2.0	96,000	2.7	0.35
1 P. M.	96,000	98,000	96,750	97,600	+0.9	92,000	2.5	0.33
2	94,000	95,000	94,600	94,700	+0.1	92,000	2.55	0.33
3	61,000	61,000	61,500	61,000	-0.8	62,000	1.25	0.15
4	61,000	60,000	61,500	60,000	-2.4	64,000	1.30	0.2
5	56,000	56,000	56,450	56,000	-0.7	64,000	1.25	0.2
6	57,000	57,000	57,500	57,000	-0.8	53,000	0.9	0.15
Totals	579,000	586,000	583,750	584,650	+0.15			
					1.2 per cent. fast.			

The variation of the specific gravity during the test was 0.668-0.677 by one apparatus, 0.661-0.662 by another.

It is to be noted that the manometer gives a good readable

differential pressure for a small loss of head while the gas is passing through the meter,—a great advantage over the Pitot and orifice types.

#### PITOT METERS.

This is the most fascinating of all the devices for measuring gases, since the simplicity is attractive and it contains the possibility of being an accurate means of measuring volumes.

The principles of the Pitot meter are generally well known. The Pitot tube measures the velocity of the flow of gas at the point where it is located in a pipe by showing the velocity head caused by the impact of the current on a pressure gauge, the other arm of which is balanced by the pressure in the pipe, called the static pressure.

The general formula for measuring the flow of gas by the Pitot meter and by an orifice is

$$Q = 218.44Ed^2 \frac{T_s}{P_s} \sqrt{\frac{hP}{TG}} \text{ in which}$$

$Q$  = flow in cubic feet per hour at  $T_s$  and  $P_s$

$E$  = efficiency of the Pitot tube or orifice

$d$  = diameter of the pipe or orifice, inches

$T_s$  = absolute storage temperature base, degrees Fahrenheit

$P_s$  = absolute storage pressure base, pounds per square inch

$h$  = height of water column in inches

$P$  = absolute pressure of flowing gas, pounds

$T$  = absolute temperature of flowing gas

$G$  = specific gravity of flowing gas, air = 1

The calculation of a varying flow in the same pipe under the same conditions is quite simple theoretically, since  $h$ , the water pressure in the differential gauge is the only varying factor and the rest may be grouped in one quantity; but practically it is difficult to determine  $h$ , the differential pressure correctly, and the value of  $E$ , the efficiency, is uncertain.

As a means of measuring gas in large volumes, the method of inserting a Pitot tube in a main in a predetermined position, can merely serve as a rough indicator and may be wrong to the extent of 10, 20 or more per cent.



In order to profit by the possibilities of the Pitot tube for accurate measurement it is necessary to be much more painstaking. The aperture to the static pressure connection must be such that it is not influenced by the flow of the gas current. The pipe is divided in five concentric annular rings and four readings are made in the center of each ring on two diameters for the dynamic pressures, and the square roots of the twenty readings are averaged.

From the experiments made by W. C. Rowse, in the laboratories of the University of Wisconsin, he derived the following general results and conclusions in part:

"If a Pitot tube is inserted in a pipe conveying gas and a traverse made over the cross-section of the pipe, it will be found that the highest velocity exists at the center of the pipe and the lowest at the walls.

"For this reason it has been customary for experimenters to determine the particular point in the cross-section of the pipe where the velocity corresponds to the mean velocity of the whole cross-section, and to keep the tube at that point for the determination of the quantity of flow as computed from the velocity readings. This point varies according to the condition of roughness of the interior surface, and other accidental conditions of the pipe in which the tube is inserted, and it is necessary to determine it for each particular pipe used.

"When a tube is to be used as a permanent gas meter, it is better, because of the fact just noted, to construct the pipe with extreme care, having the interior of uniform size and highly polished, and then to place the tip in the exact center of it. This necessitates the inclusion in the theoretical formula of a factor called the "efficiency" of the tube, in order to reduce the flow, as indicated by the tube readings to the mean velocity.

"The Pitot tube as a means of measuring gases is reliable within approximately 1 per cent. when the static pressure is correctly obtained and when all readings are taken with a sufficient degree of refinement; in order to obtain this degree

of accuracy the Pitot tube should be preceded by a length of pipe 20 or 38 times the pipe diameter, in order to make the flow of gas as nearly uniform across the section of pipe as possible.

"All the methods of obtaining the dynamic head used in these experiments give accurate results.

"The most reliable and accurate means of obtaining the static pressure is the piezometer, or its equivalent, the results of 138 tests using the piezometer static pressure agreeing with the Thomas meter within an average of 0.33 per cent.; these results show beyond any doubt that the static pressure is constant across any section of a pipe in which gas is flowing at a uniform rate.

"Of the methods of obtaining the static pressure by the Pitot itself, the most reliable and accurate is by means of a very small hole  $1/50$  in. diameter, in a perfectly smooth surface.

"Long slots for obtaining the static pressure, are not reliable and give results which are in error from 3.5 to 10 per cent.

"It appears that an approximate relation exists between the mean velocity head of a gas flowing through the pipe and the velocity head found by placing the tube in the center of the pipe. For a 12 in. galvanized pipe results within 2 per cent. may be expected by taking the mean velocity head as 0.80 of that at the center.

"The accuracy of the measuring instruments used is much greater than can be expected from the Pitot tube as a means of measuring gases, due to the uncontrollable variation in the gas flow. The considerations which may prevent even an absolutely correct Pitot tube from giving true results are as follows:

"The gas flows through the pipe in a wave or spiral motion and at no time is the velocity uniformly distributed across the pipe, being greater in one quarter than in the other three quarters; the quarter of highest velocity may or may not be on the diameters where Pitot tube readings are taken.

"The velocities on the diameters where Pitot tube readings are being taken may be constantly varying during the period of time necessary to obtain the readings; thus the average of all readings may be slightly too large or too small.

"The gas flow can only approach, never reach, the ideal conditions of parallel flow and the Pitot tube is correct, theoretically, only when the tube is exactly parallel to the current."

The ingenious devices for reading small differential pressures have been described many times. These are based on the principle of using an inclined gauge to multiply the motion and of using some other and lighter liquid than water and one with less adhesion to glass, such as ether, alcohol, gasoline or kerosene, of which the specific gravity must be known.

For differential pressures of 1 in. or more a U tube manometer may be used. For this pressure, an error of  $1/20$  in. in the reading corresponds to  $2\frac{1}{2}$  per cent. in the measurement.

But a pressure of 1 in. of water with gas of 0.500 specific gravity corresponds to a velocity in the pipe, of nearly 100 ft. per second. This is rarely attained with artificial gas.

With the inclined manometer, some experimenters have succeeded, under very favorable conditions, in measuring gas with  $1/10$  in. differential. Here an error of  $1/100$  in. is about 6 per cent. Usually vibration prevents any such close reading. This corresponds to the rapid flow of about 30 ft. per second, or a loss of pressure in 1,000 ft. of 12 in. pipe of 2.6 in.

It is possible, with a gauge slanting 40 to 1 and with a mobile liquid, to measure velocities of 8 feet a second with some satisfaction

The recent progress in velocity measurements has been in the direction of recording instruments.

#### CALIBRATED ORIFICES.

The method of measuring large quantities of gas by calibrated orifices is such a rough one that it would scarcely be applied to artificial gas. There must be a considerable loss

of pressure to obtain a significant measure of the quantity, and back pressure is objectionable.

The size and shape of the orifice or mouth piece influences the coefficient of efflux, which also changes for varying differential pressures.

The method is quite satisfactory for controlling the flow of air under constant conditions, as from a blower to a water gas generator.

A simple formula for the flow of a gas through a circular orifice in a thin plate; due to small differences of pressure, and at ordinary temperature is:

$$\text{Velocity, feet per second} = 40\sqrt{\frac{\text{Press. in inches of water}}{\text{Specific gravity}}}$$

Data on this subject is given in all mechanical text books and concisely in Kent's Pocket Book.

A calibrated orifice must be used under very nearly the same conditions as in calibration and must be exactly of the same shape when duplicated.

Neglecting either of these conditions may involve a change of 10 per cent. in the efficiency.

If one were relying implicitly on this measurement, a change of 10 per cent. in the amount of air blown into a water gas generator would make a great difference in the temperature.

A related method of measuring gas is by its loss of pressure by the flow through pipes. It is cruder and more uncertain because it involves in addition the friction of the length of pipe, but it will serve as a guide in some investigations. The formulae have their field for usefulness in the design of pipe lines.

The oldest formula, Dr. Pole's, is applicable to low pressure gas and is:

$$\text{Cubic feet per hour} = 1350d^2 \sqrt{\frac{pd}{sl}} \quad \text{wherein}$$

$d$  = diameter in inches

$p$  = pressure in inches of water

$s$  = specific gravity

$l$  = length in yards

The measurements by the Pitot tube and by calibrated orifices are both based on the same physical law and involve the difficulty of reading slight differences of pressure.

The Pitot tube has the advantage of not interfering with the flow of gas; but the process of searching the whole main for impact pressures is quite complicated and gives results that are rather uncertain from the currents, and, although taking a single observation is simpler, it is still more uncertain.

The orifice device has the advantage that both high and low pressures are taken as static pressures and with small relative error; but it involves the trouble of inserting a diaphragm or nozzle in a pipe line with the serious disadvantage of causing back pressure, to obtain the same convenient difference of pressure that is obtained by the Pitot by impact of the current.

#### ANEMOMETERS.

An anemometer is a mechanical device to show the velocity of a gas in a conduit, by registering the revolutions caused by the impact of the current on the revolving vanes.

Besides the difficulty of duplicating one, it has the handicap of being very delicate in construction and liable to respond differently to the current, at different times. Also, the velocity of the gas varies in different parts of a conduit, so that it gives a very inaccurate indication of the velocity, or at least uncertain.

#### ROTARY METERS.

A rotary meter is built on the plan of an anemometer, but is a much more reliable indicator, because a constant proportion of the flow of gas at the varying velocities impinges on the vanes of the registering device.

When accurately calibrated and in good order, it is a serious competitor of the station meter for accuracy at a wide range of rates.

It has great advantages over the station meter of the same capacity in convenience and cost.

It has the disadvantages that its mechanism is delicate, and

that the pipes and impact tube may become partially clogged by material deposited from the gas and will then register incorrectly in one direction or the other.

Its condition as to cleanliness may be ascertained without much difficulty by inspection. The accuracy of its mechanism either originally or occasionally can be determined only by a test against a station meter or a holder, for there is no external indication except stopping.

One large gas company has had experience with them with rather mixed results. Two small ones, which are used for measuring air to purifiers, were correct when new within 2 per cent., at the range of rates guaranteed. They have been clogged by moist dust several times in 5 years, but after cleaning, they have registered as correctly as in the first place.

Of two meters of 250 M hourly capacity, installed as works meters on water gas, with connections for testing by a wet station meter at pleasure, one tested when new

at the rate of 35 M per hour .....	3.5 per cent. fast
at the rate of 50 M per hour .....	1.8 per cent. fast
at the rate of 100 M per hour .....	0.8 per cent. fast
at the rate of 150 M per hour .....	0.8 per cent. fast
at the rate of 200 M per hour .....	1.6 per cent. fast
at the rate of 220 M per hour .....	1.4 per cent. fast

the other one was 2.8 per cent. fast on the average. This second one had the gear changed to correct it. After being used on water gas for four winters, both tested within 1 per cent. at the guaranteed ranges and were found clean on inspection. They have had no repairs.

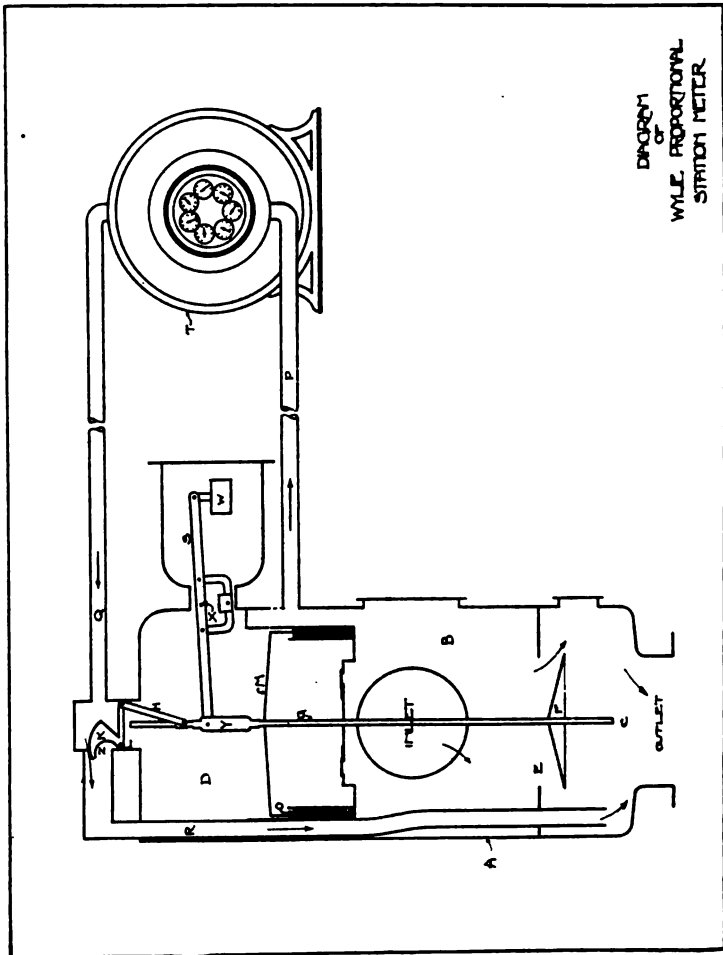
This experience is, on the whole, very satisfactory, but it proves the necessity of control and inspection.

#### PROPORTIONAL METERS.

In the proportional meter only a fractional part of the full volume of gas passing through the apparatus is measured and from such measurement the total volume is determined. The mechanism of the apparatus is designed to maintain at all rates of flow a constant ratio between the large unmeasured volume and its fractional measured component.

The Wylie Proportional Meter and the Westinghouse Pro-

portional Meter are notable examples of this type of meter. Both are used extensively for measurement of natural gas. The Wylie Meter is used to measure manufactured gas in



several gas works as a station meter. A description of its construction and operation is as follows:

The meter consists essentially of two parts; the main shunt and the tally. The latter is a small wet meter, which measures

a fractional part of the total unmeasured volume flowing through the shunt. The tally dial is geared to register the total volume.

In the main shunt there are two valves, mechanically connected so as to operate in unison, and controlled by a diaphragm. The large valve controls the main or shunted volume passing through the shunt, and the smaller valve, the coefficient or fractional volume measured by the tally. The object of the mechanism is to obtain and maintain a constant ratio of pressure absorption or drop through the proportionate valve openings.

In the illustration, A is the main shunt, provided with an inlet and outlet divided by partitions into three chambers or compartments B, C and D. The opening E between the inlet compartment B and the outlet compartment C is controlled by the valve F, which is mounted on the lower end of the vertical valve stem G. The upper end of this stem is connected with the coefficient valve K, controlling the opening Z. This valve is pivoted at L, and is operated by means of the connecting rod H, attached to G.

The diaphragm M is in the form of a holder bell, rigidly secured to the valve stem G, and separating the compartments B and D, by means of the annular seal O. In some types a dry diaphragm sealed with flexible material is used. The inlet compartment B communicates with the inlet of the tally T, by the pipe P the outlet of tally communicating to compartment D by pipe Q which conveys gas from tally meter through the coefficient valve K and pipe R to the outlet compartment C. The valve stem G and its appurtenances is counterweighted by the weight W, suspended from the end of the lever S, which is fulcrumed on a fixed pivot X and connected to G by a link at Y. The weight W, is sufficient to close the valves when no gas is passing. The ratio of the area of the openings E and Z, controlled by the proportionate valves, is predetermined and is equal to the ratio of the determined capacity of the tally meter to the volume passing through the main shunt. The effective area of the diaphragm M is larger



than that of the valve F, which must also be considered as a diaphragm acting in opposition to M. The effective area of M, is usually made double the area of F. Suitable differential pressure gauges are attached which indicate the pressure absorbed by the shunt and tally.

#### THE OPERATION IS AS FOLLOWS.

Gas enters B through inlet in the direction indicated by the arrows. The area of M being greater than F, the first tendency would be to maintain F in a closed position until some gas had passed through P and the tally into compartment D. The outlet pressure of the tally acting on M causes the stem G to descend, opening F and K, and to assume a position in which equilibrium is established between the pressures acting on F and M.

In order that the ratio of the volumes of gas passing through openings E and Z may be constant, it is necessary to preserve a constant ratio between the differential pressure or drop through these openings. This is accomplished by the diaphragm M, as follows: As the valves are in equilibrium, it is evident that the total effective pressure exerted on M is equal and opposite to the total effective pressure acting on F. The effective pressure acting on F, is its area multiplied by the drop of pressure through the opening E, which is the total differential absorbed by the apparatus. Similarly, the effective pressure acting on M is its area times the drop through the tally. Since these quantities are equal, and since the area of M is twice that of F, it is evident the drop through the tally is one half the total drop between inlet and outlet, and the other half must be the drop through the opening Z, controlled by the coefficient valve K. The ratio of drop through E and Z will therefore be constant irrespective of what ever predetermined ratio is assigned between the areas of M and F. As gas in passing through the tally must lose some pressure, whenever there is a variation in the amount of pressure absorbed by the tally the diaphragm M will move the stem G into a new position of equilibrium, thus varying the openings E and Z, in response to the variations of volume.

In order to demonstrate the theory of operation, let us assume that in a certain given position of the valves,

$V$  = volume passing through  $E$

$v$  = volume passing through  $Z$

$D$  = total differential or drop through  $E$

$d$  = drop through tally

$D - d$  = drop through opening  $Z$ .

$R$  = ratio of areas of proportionate valve openings.

$r$  = ratio of areas of diaphragms  $M$  and  $F$

Theoretically, the flow of gas through an orifice or opening is directly proportional to the area of the opening and to the square root of the drop of pressure through the opening. Assuming the area of  $Z$  to be 1, the ratio of the volumes is

$$\frac{V}{v} = \frac{R\sqrt{D}}{\sqrt{D-d}} \dots\dots\dots (1)$$

again, assuming area of  $F = 1$ , and since the diaphragms are in equilibrium.

$$D = dr \dots\dots\dots (2)$$

substituting this value in equation 1, we have:

$$\frac{V}{v} = \frac{R\sqrt{dr}}{\sqrt{dr-d}} = \frac{R\sqrt{dr}}{\sqrt{d(r-1)}} = \frac{R\sqrt{r}}{\sqrt{r-1}}.$$

As the values  $R$  and  $r$  are constant and predetermined, it follows that the ratio of the fractional volume measured by the tally to the volume passed by the shunt is constant so long as the ratio of pressure differential through the proportionate openings is maintained constant. The accuracy of the meter, therefore, depends upon three elements; the tally, freedom from obstruction of the parts by foreign matter and the elimination of friction in the parts of shunt.

#### SIZES AND CAPACITIES OF WYLIE PROPORTIONAL STATION METERS.

Size of connections inches	Height of shunt overall inches	Capacity cubic feet per hour
8	60	75,000
12	72¾	100,000
16	78½	180,000
24	—	500,000

#### WESTINGHOUSE PROPORTIONAL GAS METER.

This meter is used for natural gas. The makers do not

recommend its use for manufactured gas. The 12 in. size is listed to pass 150,000 per hour. Larger size are made to order. It is smaller and more compact than that type of the Wylie Meter which is designed for Station Meter use on artificial gas.

Proportional Meters should not be used in locations where the flow of gas is pulsatory as is the case when connected near a positive exhauster. The connections to the inlet and outlet of the meter should preferably be at least 5 ft. or 6 ft. of straight run of pipe rather than elbows or bends and when used for station meter work it is advisable to provide means for testing its accuracy at its rated capacity by connections arranged so that it can be run in tandem with a wet drum station meter when a test is desired. The regular observation of the differential pressures is important.

#### • CALORIMETRIC METERS.

A calorimetric meter is one in which the gas is heated or cooled and its volume is computed from the transfer of heat and the known specific heat of the gas, which is passing.

The electric gas meter invented by Prof. C. C. Thomas is of this type. It appears rather useless to give an extended description of the apparatus and of the theory of its action, since this is to be found in an article of 40 pages in the Report of the American Gas Institute of 1912. In that is a full and clear account and it contains many items and suggestions of practical interest to gas men.

Also, in the Journal of the Franklin Institute for 1911, there is a paper by Prof. Thomas on "The Measurement of Gases" covering 50 pages, which treats the whole subject and gives a more complete description of the principles of the electric meter.

Concisely, the action of the electric meter is this:

The specific heat of 1,000 cu. ft. illuminating gas is very close to 21 B. t. u. The gas is heated by an electric heater a constant amount, say 2 degrees, and the heating is controlled by electric thermometers. The electric energy for heating can

be measured very precisely. Then, since the heat equivalent of a kilowatt is 3,415 B. t. u., the volume in thousands of cubic feet of gas measured by the meter is  $\frac{3,415}{21 \times 2}$  per kilowatt hour.

One of the considerations in operating this meter is that the mechanism is much more complicated than that in any other measuring device. Since it is continually in motion and must act with precision, this implies much more attention than is given a station meter.

The meter is easily checked and corrected during a short interruption of the measurement. The two factors are the temperature rise and the current.

One feature of such a heater in the form of a screen in a gas conduit seems rather objectionable in a works which is troubled with naphthalene in that it would be liable to clog up. But the rise in temperature hinders the deposit. Deposits made the meter somewhat slower in responding to a change of flow.

It is possible with these meters to measure very large volumes with a single unit. The one in Milwaukee is of 3,000,000 ft. per hour capacity.

The usual range of accurate registration is 30 to 1. They are now also furnished with a range of 50 to 1.

The Thomas electric meter has been regarded as reliable by several experimenters who have made very careful comparisons of the Pitot, Venturi and electric meter in measuring very large volumes of air and natural gas. It appears to be winning favor in this latter field, where it is especially suited, on account of its large capacity, for size and cost, to measure the maximum delivery from a pipe line to a town on the line. It is hoped that a great restraint in the waste of natural gas will be effected if the volumes are measured positively, so the unaccounted for gas may be traced with assurance.

The maximum flow of natural gas to a town is often 30 times the minimum.

## SELECTION OF A METER.

This discussion of the limitations of the meters for large quantities of gas may influence the choice of one for a particular purpose. The questions of confidence, convenience, accuracy and cost will have weight.

Confidence is subjective and may hardly be disputed.

The most convenient device, the crudest Pitot tube, may, by accident, be correct under the conditions when it is used. And it is claimed and apparently proved, that a Pitot meter including a carefully prepared pipe, placed with pains in a favorable position in a line, is correct within 2 per cent., at favorable rates of flow,—over 25 linear feet per second, showing about 2/10 in. water pressure. Twenty careful readings are made on two diameters of the pipe.

Here convenience is somewhat sacrificed to accuracy; and then one cannot believe it accurate unless he proves it.

All are more convenient and much less expensive than a wet meter.

The cost of meters for large volumes of gas varies so widely that it is worth serious consideration whether an inferential meter may not sufficiently fulfil the requirements.

It is a mark of great progress in the industry that we are enabled to use one of several kinds in manufacturing and distribution for information and guidance.

We give a table of the approximate proportional original costs for capacities of about 250 M per hour:

Wet station meter.....	100
Rotary .....	50
Electric .....	38
Proportional.....	30
Venturi .....	12
Pitot .....	½

The cost of a 500 light diaphragm meter passing 5,500 ft. per hour is \$275.

It may be noticed, in comparing the largest sized diaphragm meter and a 16 ft. station meter, that the costs are as 1 to 33, and the capacities as 1 to 45.

If the station meter were rated at 180 M per hour, as it is sometimes limited, the proportions of costs and capacities would be equal, and 33 500 light meters would replace 1 16 ft. meter and almost in the same space.

It is not suggested that a battery of diaphragm meters should displace a wet station meter in the works or at any other place, especially where there would be condensation, but this illustrates the fact that measuring gas by volume displacement meters requires large apparatus.

The standard conditions for measuring and declaring the volume of gas are in cubic feet at a barometric pressure of 30 in. and at 60 deg. and saturated with water vapor at this temperature. These conditions are, in practice, strictly followed only in a calorimetric test. In a photometric test the actual excess pressure on the meter is generally ignored, although if one is working without a governor on gas entering or leaving a high holder it is worth taking into account, for it may amount to over 3 per cent.

In testing or comparing measuring devices, the conditions are seldom the standard ones on either meter, and all must be corrected to the common standard, to obtain any significant comparison; therefore, the variation from atmospheric pressure is a factor.

In measuring gas as manufactured, where formerly we took for results the figures of the meter at random temperatures, perhaps at about 60 deg. at the season of the greatest make in winter and much higher in summer, we have progressed so that most companies correct for temperature. Some in addition correct for the barometer. Then comparisons may fairly be made between different localities.

A few carry these refinements to the conclusion and correct for the pressure on the meter; this last may easily be significant enough to make a very satisfying increase in the figures of the daily results. At all events, it aids in a comparison of different times and places.

There was an argument for correcting the temperature to

60 deg. that by so doing we were approaching the temperature of the consumers' meters, and thus reducing the "unaccounted for gas." Correcting for pressure at the meters would tend to increase this unaccounted for gas, but it would also give us a truer view of the operations.

These remarks have application to displacement meters. The Thomas Calorimetric meter makes these corrections automatically, except in respect to the varying amount of water vapor in saturated gas at different temperatures. This error may be ignored. But is also compensated for by locating the temperature difference resistance coil in the gas main and by forming this coil of a material, whose resistance decreases at the desired rate with an increase of temperature.

The velocity meters, Venturi, Pitot and calibrated orifices, which must derive their results by calculation, or by calibration under fixed conditions, depend upon a knowledge of the temperature and pressure, and also of the specific gravity to indicate the flow in standard cubic feet.

Tables of corrections for temperature and pressure are to be found in many books; among others, in the 1908 and 1913 PROCEEDINGS of the American Gas Institute.

We give here the general formula:

$$\text{Volume at } 60^{\circ} \text{ and } 30'' = \text{observed volume} \times \frac{520 \left( \text{Bar.} - \text{vapor tension at } t^{\circ} + \frac{\text{inches water pressure}}{13.6} \right)}{(460 + t^{\circ}) (30'' - \text{vapor tension at } 60^{\circ})}.$$

If the pressure above atmospheric is to be ignored, the factor of water pressure is made zero.

If it is desired to declare the amount of gas at any excess pressure as 3 in. pressure, instead of at the meter inlet pressure, this may be done by adding to the volume corrected by the factor for temperature and barometer, at 60 deg. and 30 in., 1 per cent. for every 4 in. less than the meter pressure.

A table of factors to add to the metered amounts reduced to 60 deg. and 30 in. barometer for any meter inlet pressure to several base pressures follows:

Meter pressure	Base pressure and per cent. added				
	2"	3"	4"	5"	6"
4"	0.50	0.25	—	—	—
5"	0.75	0.50	0.25	—	—
6"	1.00	0.75	0.50	0.25	—
7"	1.25	1.00	0.75	0.50	0.25
8"	1.50	1.25	1.00	0.75	0.50
9"	1.75	1.50	1.25	1.00	0.75
10"	2.00	1.75	1.50	1.25	1.00
11"	2.25	2.00	1.75	1.50	1.25
12"	2.50	2.25	2.00	1.75	1.50
13"	2.75	2.50	2.25	2.00	1.75
14"	3.00	2.75	2.50	2.25	2.00
15"	3.25	3.00	2.75	2.50	2.25
16"	3.50	3.25	3.00	2.75	2.50
17"	3.75	3.50	3.25	3.00	2.75
18"	4.00	3.75	3.50	3.25	3.00
19"	4.25	4.00	3.75	3.50	3.25
20"	4.50	4.25	4.00	3.75	3.50

Artificial gas, confined over water, is assumed to be saturated with vapor of water.

It has been the aim of the committee in preparing this report to include such information as would be interesting and helpful to manufacturers of artificial gas in the important branch of measuring the product.

That it contains little that is original or novel must be excused by the fact of the recent popularity of the subject of measuring gas as evidenced by the many and voluminous papers on the art and apparatus scattered through different journals lately, in which nearly everything that can be said has been said, and in which even simultaneous duplication of laborious experiments have been noted.

The following papers are quite extensive and contain valuable information on the apparatus and theory of the newer devices for gas measurement, with many illustrations:

**The Measurement of Gases**, by Prof. C. C. Thomas, *Journal of the Franklin Institute*, 1911. 40 pages.

**Some Recent Developments in Gas Measuring** by Prof. C. C. Thomas, *Proc. American Gas Institute*, 1912. 40 pages.

**Flow of Gas in Mains**, by W. F. Batten, *Proc. American Gas Institute*, 1911. 30 pages on the Pitot Meter.

**Measurement of Flow of Gases in Mains, by Means of the Pitot Tube**, by A. R. Griggs, *Journal of Gas Lighting*, 1912.

**Measurement of Air in Fan Work**, by C. H. Treat, *Journal Am. Soc. Mech. Engineers*, 1912 and 1913. 36 pages on Pitot Tube.



- Measurement of Natural Gas, by Thos. R. Weymouth, Journal Am. Soc. Mech. Engineers, 1912 and 1913. 20 pages on Venturi and Pitot.
- Venturi Meter, by E. P. Coleman, Trans. Am. Soc. Mech. Engineers, 1909. 12 pages.
- Pitot Tubes for Gas Measurement, by W. C. Rowse, Journal Am. Soc. Mech. Engineers, 1913 and 1914. 65 pages.
- Measurement of Natural Gas in Large Quantities with Pitot Tubes, by B. C. Oliphant, 1912, Report of the Natural Gas Association.
- Measurement of Gases in Large Quantities, by J. C. Wilson, 1914. Report of Natural Gas Association. 52 pages on Inferential Meters.
- Measurement of Artificial Gas in Distribution Systems, by J. C. Wilson, Wisconsin Gas Association, 1914. About 25 pages on the Electric Meter.

(Dr. Wing read an abstract of the report.)

THE ACTING CHAIRMAN: Before taking up the discussion on this paper, the Chairman of the Nominating Committee would like to make a report.

#### REPORT OF THE SECTIONAL NOMINATING COMMITTEE.

MR. W. CULLEN MORRIS (New York): I have been advised that Mr. R. B. Brown, one of the three nominees that the Committee presented to the meeting yesterday, has withdrawn. I have endeavored to see all the members of the Committee since, but I have not seen all of them, though I have gotten in touch with the majority of the Committee. They have suggested, as a substitute for the name of Mr. Brown, that of Mr. Herman Russell. I think it should be acted upon to-day.

THE ACTING CHAIRMAN: You have heard the report of the Chairman of the Nominating Committee. What is your pleasure?

CAPT. W. E. MCKAY: I move that the Secretary of the section be instructed to cast the ballot of the section for the name as designated, as one of our candidates for Vice-President.

Motion seconded.

THE ACTING CHAIRMAN: It has been moved and seconded that the Secretary cast one ballot for the name designated by the Nominating Committee. All those in favor will answer in

the usual manner. (Ayes.) Opposed. (No response.) It is carried.

THE SECRETARY: I so cast the ballot.

THE ACTING CHAIRMAN: We will turn now to the discussion of the Report of the Committee on the Measurement of Gas in Large Volumes. Is there any discussion on this report?

MR. J. W. BATTEN (Detroit): From the standpoint of efficient operation of a plant, accurate measurement of the various component gases forming the final gas for distribution, is recognized as a prime necessity. The method to be adopted for obtaining this information must possess the merit of recognized dependability under various conditions of temperature, pressure, and cleanliness of the gas. A large proportion of the various types mentioned in the report of Dr. Wing's committee has met the conditions required in a few plants, to the complete satisfaction of the operator. Very few on the contrary, have commended themselves to gas men as a body, viewed from the aspect of accuracy and continuous reliability.

During the past year, the Detroit City Gas Company has had a Thomas electric meter in operation at its Station A plant. As explained in the report, the fundamental principle upon which this meter operates, is that the specific heat of a given gas at all reasonable temperatures and pressures is a fixed quantity. The operation of the meter consists in the increasing of the temperature of the gas passing through it by a definite number of degrees, this increase in temperature being accomplished by the interposition of an electric resistance and being automatically controlled within the limits of accuracy desired.

For success, such a meter must take cognizance of:

First: The maintenance of a constant pre-determined difference in temperature between the thermometer coils, and the ability to readily check up the meter to see that this desired differential temperature is maintained.

Second: The accuracy of the watt meter. The latter, of course, may be checked by comparison with a standard watt meter of known accuracy. The delivery by the

heating units of the desired temperature difference may be checked by the removal of the resistance representing the rise in temperature, and the resulting balance of the Wheatstone bridge shown by the return of the galvanometer needle to its zero position.

Inasmuch as the watt meter registers energy, later transformed quantitatively into heat, and as the heat required to raise 1 cu. ft. of a given gas 1 degree under any conditions desired by the user is constant, the dial of the meter can obviously be made to read in terms of cubic feet, with no subsequent corrections for variation in temperature and pressure. Changes in the water vapor content and in the composition of the gas, affect this specific heat and consequent accuracy of the meter. Theoretically, in normal practice these are small. In actual operation, using the same gas, we have found that they may be neglected. The use of this meter on coal gas, if the heater coil has been designed for water gas, does necessitate for accurate work, the use of a small correction factor, usually not greater than 2 per cent., depending on the variation of the analysis of the gas being measured from that on which the heating coil was based.

Checks on the accuracy of this meter, which is of 500,000 cu. ft. per hour capacity, were carried on by comparison with a 16-ft. wet meter, and also a 500,000-ft. holder enclosed in a brick building, the latter giving particularly favorable conditions for such a test. Three tests conducted at intervals throughout the last eight months give results as follows:

0.14 per cent. slow

0.37 per cent. fast

0.26 per cent. fast

During the early weeks of the operation of this meter, difficulties were encountered such as corrosion and consequent change of resistance of thermometer coils. These difficulties have, however, apparently, been eliminated as the above tests would indicate. During this period, the attention given the meter consisted in, first, supplying oil to bearings and moving parts twice a month; second, removal and replacement of tape

records monthly; third, balancing of the instrument by cutting out the heater coil and observing the action of the galvanometer needle. This may be done as frequently as once each week, 15 minutes being required.

No deposits have been discovered on the coils or the heater. None would be expected, as their temperature is higher than that of the gas, though deposits could have no effect on the accuracy of the meter.

This meter is a radical departure, in principle, from that of all other present day methods of measurement of gas in large volumes. After an experience of eight months in the measurement of water gas at varying temperatures, and hence of varying water content, and with considerable fluctuation in the per cent. of illuminants, it is our opinion that this meter should be given serious consideration from the viewpoint of accuracy and continuous reliability.

MR. J. S. KENNEDY (New York): Mr. Chairman, I would like to ask Mr. Batten if he can tell us what is the operating cost in kilowatt hours per 1,000,000 cu. ft. of gas measured? I made a calculation here from the formula on page 699, and roughly figuring, I got 12 kilowatt hours per 1,000,000 ft. of gas measured. At 5 cents a kilowatt hour, that would be 60 cents, or about \$1.20 for a 2,000,000 per day registration.

MR. BATTEN: The cost of our current amounts to about 1.2 cents per kilowatt hour. On that basis, the cost of operating the meter amounts to about 1 cent per 75,000 ft.

MR. KENNEDY: I would like to ask whether the electric type meter is affected by a pulsatory flow of gas.

MR. BATTEN: We had no difficulty in that respect. The meter is on the outlet of a water gas exhauster. Of course, the water gas exhauster delivers through the purifiers, and the pulsation is not noticeable under those conditions.

MR. KENNEDY: There is another point which I want to bring before the Institute, with a view to getting a little discussion. When we come to determine the accuracy of the inferential meter, it is usual, at least so it is stated in this paper, to compare the inferential meter against the registration of a

positive wet drum meter. The positive wet drum meter is calibrated at a low volume and used at a much higher volume. The rate of flow at stated capacity is very much in excess of the rate at which it is tested.

I do not think we have any grounds for assuming that because it is accurate at a low volume, it is equally accurate at a high volume, particularly when we consider that meters of the positive or displacement type are largely affected by friction, and that the friction increases with the speed or the rate of flow. Meters of the inferential type are automatically corrected for the errors which might be induced by friction, because the friction would increase with the pressure or velocity, and this is one of the elements or factors which governs the operation of an inferential meter. I think you will find in comparisons of the inferential meter with a positive meter at high rates of flow, that the inferential meter is apparently fast. It may be true that it is quite accurate, and the station meter or wet drum meter with which it is compared is actually slow. The makers of the wet drum station meter state that at the higher rates of flow, the depression in the water line, which takes place in the measuring compartment, is automatically taken care of by the inflow of water. I could never feel that this was true, because variations in the rate of flow may take place at a much faster rate than the water could get into, or out of, the inside of the meter to compensate for the variations of water level. I should like to hear from the other gentlemen as to how they feel on this particular subject.

MR. C. H. HODGES (New York): One thing I would like to speak of concerning the measurement of gas from a works' standpoint. The barometer will run anywhere from 29 to 31 in. and this variation will make a difference of 7 per cent. in volume of the gas. Take a water gas plant and this variation will make a difference of over 2 lbs. of generator fuel and  $\frac{1}{4}$  gal. of oil per thousand. Consequently, one often looks for trouble that is really due to the weather changes. Therefore, I think that gas at the station meter should be corrected for barometer.

MR. J. M. SPITZGLASS (Chicago): I have already benefited by this report. I had to test a few proportional meters lately. I was very glad when I found, especially as I did not know

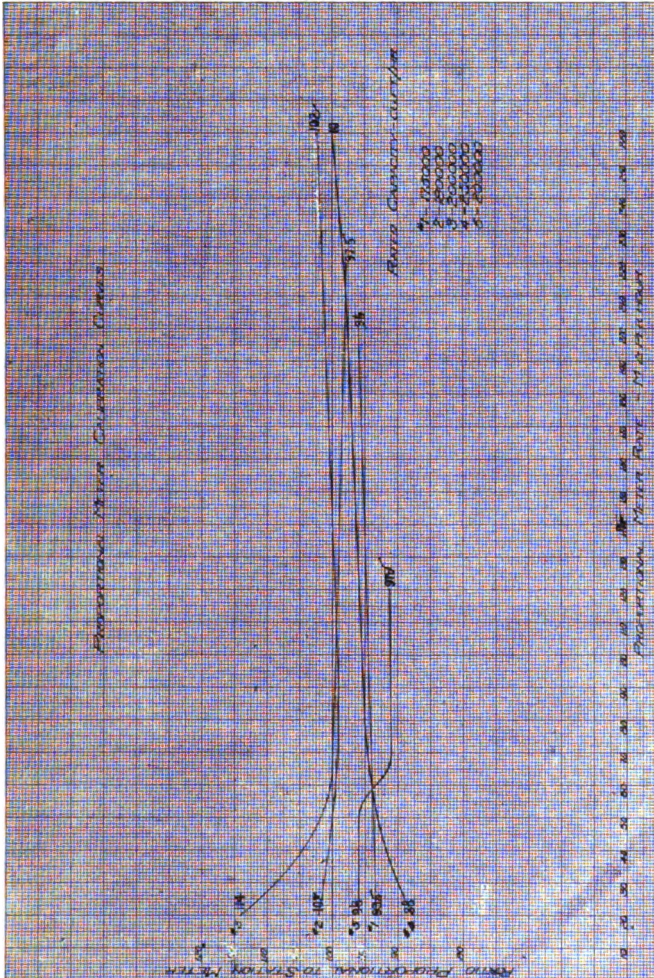


Fig. 1.

much about the construction of these meters, that I had such detail here that I could go by. I have a diagram here showing correction curves for five of the meters I have tested against

a station drum meter. The horizontal scale of the diagram represents the proportional meter rate in thousands of cubic feet per hour; the vertical scale represents the station meter rate in the same manner. (Fig. 1.) Here are the rated capacities of those meters, beginning with 175,000 up to 250,000 per hour. The curve for No. 1 beginning with 93.5 per cent. at the lower capacity follows practically in a straight line up to 96 per cent. at the higher capacity. No. 2 begins with 102 per cent., and then goes down lower and comes up again to 102 per cent. This one is very good. No. 3 has 114 per cent. on 20,000 per hour. It comes down to 100 per cent. on 60,000 per hour, ending with 97.5 per cent. at the highest capacity, on 220,000 per hour. No. 4 begins with 88 per cent. on the lowest, comes up to 100 per cent. on the highest capacity. This is the way we found them after they were three years in operation.

I was at odds with this report for a while, for it said that the Pitot tube may be wrong to the extent of 10 to 20 per cent. or more, but when they said in the same paragraph that it contains the possibility of being correct, that pacified me, as I thought I will get that possibility and will make it correct. I refer to the equal-area Pitot tube mentioned in the previous paper. That Pitot tube was designed to take care of the points which tend to make the measurements of the ordinary Pitot tube inaccurate. Those points are characterized in the first paragraph on page 688, which says: "In order to profit by the possibilities of the Pitot tube for accurate measurement, it is necessary to be much more painstaking. The aperture to the static pressure connection must be such that it is not influenced by the flow of the gas current. The pipe is divided into concentric rings and so on." These points are taken care of, first, by making the openings for the static pressure directed from the flow, so as to have the calibration take care of the full syphoning action of the flow, and second, by having the tube instead of the pipe, divided according to the equal-area concentric rings of the cross section of the flow.

The openings of the tube are laid out according to the following equation:

$$R_x = R \left( \frac{2X - 1}{N} \right)^{\frac{1}{2}}.$$

Where  $R_x$  is the distance from the middle of the tube to any consecutive opening;  $R$  is the radius of the pipe, or half the length of the tube;  $X$  is the number of the opening from the center; and  $N$  is the total number of openings in the tube.

With a set of tubes laid out in this manner, the differential gauge to which the tubes are connected will indicate the true velocity in the pipe, without any special effort on the side of the operator.

MR. L. C. ROGERS (Hutchinson, Kan.): (Written discussion communicated.) Dr. Wing's report constitutes an important contribution to the technique of gas measurement, and credit is due him for the clear and concise manner in which he has treated his topic.

The writer of this brief discussion has had considerable experience with all of the types of meters mentioned by Dr. Wing, using both natural and artificial gas, and a few brief notes may serve to throw additional light upon the rather difficult problem of gas measurement.

As pointed out in the paper, the station meter is the most accurate and reliable instrument which we have for measuring gas in large volumes. The principal disadvantages of station meters are high initial, installation and repair costs, and the large space required.

Not long ago the writer was requested by the gas company in a large city to check up its various station meters. As very little interruption to the service could be permitted, it was necessary to use the simplest apparatus which could be employed, and yet a very close degree of accuracy was requisite. The Pitot tube or Pitot meter was selected, and a type of Pitot tube which was readily adapted to traversing the various gas mains was designed.

Briefly, this Pitot tube consisted of a solid brass tip having the usual velocity opening in front, and slots  $1\frac{1}{2}$  in. long at the



sides for the static pressure. This tip, approximately 5 in. long, was screwed into a piece of brass tubing  $\frac{7}{8}$  in. outside diameter and 4 ft. in length. The velocity pressure was transmitted through a  $\frac{1}{4}$ -in. brass pipe, which passed through the  $\frac{7}{8}$ -in. tube, and the static pressure was transmitted through the annular space between the inner and outer tubes.

At the top, the two tubes terminated in a T provided with a stuffing gland. The usual manometer connections were provided at the T. A 1-in. brass corporation cock was screwed into the main to be traversed, and a stuffing box 14 in. in length was screwed into the corporation cock. The entire arrangement made the traversing of a pipe a very simple matter.

The manometer used was the usual 1 to 10 inclined manometer, and kerosene of known gravity was used for obtaining the differential. In order to obtain the co-efficient of this tube, it was of course necessary to go through a rather elaborate series of tests. In order to facilitate this work, the gas company placed at the disposal of the writer an 18-ft. station meter. This station meter was first carefully calibrated by means of a meter prover of known accuracy. The Pitot tube was then located in the 16-in. pipe delivering gas to the meter, and an exhaustive series of traverses made at rates varying from 40,000 to 200,000 cu. ft. per hour.

The method employed consisted in dividing the area of the pipe into equal areas by means of concentric circles, and noting the differential when the Pitot tube tip was located at the center of each, and traverses were made both forward and backward, and each "run" lasted two or more hours. The co-efficient curve of the tube was found to be flat, and showed a slight tendency to rise as the velocity increased.

In plotting the curve for the value C, the values of the theoretical velocities as per Pitot tube or  $V = \sqrt{2gH}$  were plotted as abscissa, while the values of C were represented by ordinates.

Various formulas have been suggested for the Venturi meter and Pitot tube. The writer has found the following development both simple and satisfactory:

The derivation is as follows:

$H$  = the height of a column of gas of uniform density which will exert a pressure equivalent to the differential noted on the manometer.

$W$  = the weight of 1 cu. ft. of water at its maximum density = 62.426 lbs.

$w$  = the weight of 1 cu. ft. of air at  $0^{\circ}$  C. and 760 mm. of mercury barometer pressure.

I.  $H = \frac{W}{w}$ . This is the height in feet of a column of air equivalent to a differential of one foot at  $0^{\circ}$  C. and 760 mm.

Let  $S$  be the gravity of the kerosene used in the manometer referred to water (density of water = 1.00).

II.  $H = \frac{WS}{w}$ . This is the height in feet of a column of air equivalent to a differential of one foot of kerosene at  $0^{\circ}$  C. and 760 mm. of mercury.

Now let  $s$  be the gravity of the gas referred to air at the same temperature and pressure.

III.  $H = \frac{WS}{ws}$ . This is the height of a column of gas equivalent to a differential of one foot of kerosene at standard temperature and pressure.

Now, letting  $h$  = the differential in mm. of kerosene, and since 304.8 mm. = 1 ft. we may write equation III as

IV.  $H = \frac{WS h}{304.8 ws}$  for  $0^{\circ}$  C. and 760 mm.

To reduce equation IV to an expression for pipe conditions, we have the following:

Let  $P_1$  = Standard bar. pres. = 760 mm. Hg.

"  $V_1$  = Volume at  $0^{\circ}$  C. and 760 mm. = 1 cu. ft.

"  $T_1$  = Absolute temperature or  $273^{\circ}$  C.

"  $P_2$  = Absolute pres. of gas passing through the pipe  
 $= P_b + P$  when  $P_b$  is the observed barometer reading and  $P$  = Static Pres. in mm. of mercury.

Let  $V_2$  = the volume at pipe conditions.

"  $T_2$  = the absolute temperature of the gas =  $273 - t$   
 where  $t$  is the observed temperature in  $0^{\circ}$  C., then we have

$$V. \frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \text{ whence } V_2 = \frac{P_1 V_1 T_2}{P_2 T_1}, V_1 = 1.$$

Hence  $V_2 = \frac{P_1 T_2}{P_2 T_1}$ ; multiplying IV by the value of  $V_2$  we have

$$VI. H = \frac{WSP_1 T_2 h}{304.8wsP_2 T_1}. \text{ This may be simplified as follows:}$$

$$VII. H = \frac{62.426S(760)T_2 h}{0.0807sP_2(273)(304.8)} = \frac{7.065ST_2 h}{sP_2}.$$

Now let  $Q$  = the volume in cubic feet per second,

“ “  $c$  = a constant determined by calibration,

“ “  $a$  = the area of the pipe in square feet (if a Venturi meter is used  $a$  will be the throat area).

Let  $2g$  = the value of gravity. Then we have:

VIII.  $Q = ca_1 \sqrt{2gH}$ . Substituting the value of  $H$  from VIII, we have

IX.  $Q = 21.3 ca \sqrt{\frac{ST_2 h}{sP_2}}$  cubic feet per second at pipe conditions. Expressed in cubic feet per hour, IX becomes

$$X. Q = 76,680 ca \sqrt{\frac{ST_2 h}{sP_2}}.$$

In actual practice it is customary, where a series of traverses have been made across the diameter of a pipe with a Pitot tube, to obtain the average differential for corresponding positions. The square roots of these average differentials for corresponding positions is then extracted, and the average of the square roots obtained. If  $h_1$  represents the average of the square roots thus obtained, X may be written

$$XI. Q = 76,680 ca h_1 \sqrt{\frac{ST_2}{sP_2}}.$$

Equation XI may be written:

$$XII. Q = 418.2 cd^2 h_1 \sqrt{\frac{ST_2}{sP_2}}.$$

The application of the above formulae is well illustrated by the following data which recently obtained on the calibration of two Westinghouse proportional meters used in metering natural gas consumed by an alkali plant in the west. The meters were 40,000 and 50,000 cu. ft. per hour capacity, and

were operated in parallel. Just previous to the Pitot tube calibration, the meters had been calibrated by representatives of the gas company by means of calibrated orifices, and had been pronounced correct. A 10 to 1 inclined manometer was used for noting the differential obtained during the traversing of the pipe. Traverses were made at 15-minute intervals for a period of eight hours.

#### GENERAL DATA FROM TRAVERSES.

Position	Average difference in mm. of kerosene	$\sqrt{h}$
1.....	14.38	3.792
2.....	15.26	3.906
3.....	16.26	4.032
4.....	19.27	4.390
Middle.....	22.09	4.700
4.....	22.09	4.700
3.....	23.79	4.877
2.....	23.58	4.855
2.....	22.91	4.786
1.....	22.59	4.753
<b>Average</b> .....		4.479 or $h_1$
Nominal diameter of pipe in inches.....		8.00
Actual measured diameter of pipe .....		8.32
Average static pressure of gas mm. of Hg.....		39.6
Average temperature of gas in °C.....		26.25
Average temperature of kerosene in manometer °C.....		31.80
Average density of natural gas .....		0.635
Average barometer reading, mm. Hg.....		729.5
Total cubic feet of gas registered by both meters for 8-hour period.....		556,150
Equivalent cubic feet per hour .....		69,520

From Pitot tube determinations we have the following :

Theoretical velocity by Pitot tube from formula $V = \sqrt{2gh}$	67.1
Value of $c$ from co-efficient curve. ....	0.757

$$Q = 418.2 \times 0.757 \times 69.2 \times 4.479 \sqrt{\frac{0.807 \times 299.25}{0.635 \times 769.1}}$$

$$Q = 68,980 \text{ cubic feet per hour.}$$

$$\text{Difference} = \frac{69,520 - 68,980}{68,980} = 0.78 \text{ of 1 per cent.}$$

This, of course, is a fairly close agreement, and shows that the orifice method of calibration may be relied on for accuracy.

MR. C. G. RICHARDSON (Providence, R. I.): I have not prepared a written discussion on this valuable paper by Dr. Wing, but I should like to make a few remarks from an engineering standpoint concerning the Venturi meter for the

measurement of gas. We may have an idea that the Venturi meter has been only recently used for this kind of service, but such is not the fact. Mr. Herschel, the inventor of the meter, in making the report of his original experiments on the measurement of water, stated that in his opinion, the principle would undoubtedly apply equally well to the measurement of gas, air and steam.

In December, 1898, Mr. F. G. Gasche, then Steam Engineer of the South Works of the Illinois Steel Company, at South Chicago, Ill., developed a suitable thermodynamic formula for the use of the Venturi meter in measuring gas, steam, air, etc. Some years later, in 1904, the accuracy of this formula was tested at the Illinois Steel Company's plant in the measurement of steam, the total weight being obtained by discharging steam through a condenser, and then weighing the condensate. The results were highly satisfactory, showing less than 1 per cent. error.

In December, 1906, Mr. E. P. Coleman, Steam Engineer of The Lackawanna Steel Company, Buffalo, presented before the American Society of Mechanical Engineers, a paper entitled, "The Flow of Fluids through a Venturi Tube." This paper gave actual results from tests on the measurement of gas.

About two years ago, the engineers of the Illinois Steel Company issued a volume of about 100 pages, entirely devoted to the use of the Venturi meter for the measurement of liquids and gases, especially the latter. This volume briefly stated the experience of the Company with the Venturi meter for this kind of service, gave formulas, results of tests, proportions of meter tubes, etc., and, in fact, reduced the problem to definite standards. At the present time, the United States Steel Corporation is making extensive use of the Venturi meter for the measurement of gas.

The engineers of the Builders Iron Foundry, of Providence, R. I., manufacturers of the Venturi meter, have devoted much attention to the subject for a number of years.

I think that most of you know that the Venturi meter is composed of two main units, the meter tube and the registering instrument. The meter tube is placed in the pipe line through which the gas flows, and is made in several sections. In the middle is a contracted portion, called the throat, and smaller in diameter than the inlet and outlet end of the meter tube which match the diameter of the main pipe line. As the gas flows from the inlet towards the throat of the meter tube, the velocity greatly increases and causes a temporary drop in pressure at the throat. The difference in pressure between the inlet and throat of the meter tube is proportional, according to definite laws, to the rate of flow through the throat. Two pressure pipes, one from the inlet and one from the throat of the meter tube are led to a manometer or to a registering device. The former indicates the rate of flow in cubic feet per hour or per day on a graduated scale, as shown by the difference in level of water or mercury in the two legs of the manometer. The register is a much more complete device; it indicates the rate of flow on a circular dial, records this rate continuously on a chart and gives the total cubic feet on a counter dial.

Attention should be called to the very high differential pressure which is obtained between inlet and throat of the meter tube, amounting to about 20 in. water on low pressure gas or 20 in. mercury on high pressure gas. A very large force is, therefore, available to operate a registering device as compared with other means of measuring.

Another point often misunderstood is the possible drop in pressure, due to the contracting of the meter tube at the throat; for instance, the contraction of a 12 in. diameter pipe to a 6 in. diameter at the throat. Attention is called again, however, to the fact that the drop in pressure at the throat is only temporary, since after the gas passes the throat, the velocity begins to decrease and the pressure to be restored. When operating at the maximum capacity for which the meter is adapted, the total loss in pressure between the inlet and outlet

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of the meter tube for low pressure gas is only 2 in. water. Normally, however, the Venturi meter operates at about one-half the rate of capacity, and at this point, the permanent loss of pressure is only 0.5 in.

As Dr. Wing has stated, special corrections have to be made to the readings of the meter for variation in temperature, pressure and specific gravity. It is known definitely how to modify the apparatus to correct automatically for these variations, but up to this time, it has not been thought advisable to complicate the simple mechanism at present employed by such attachments. Therefore, a correction table of similar arrangement to the ordinary tables in use is furnished for such factors for variations in any one or all three of the factors above noted. It would also be an easy matter to place in the pipe line a temperature recording gauge or pressure recording gauge or both, the chart of which could read directly in correction factors, so that one could easily take the chart from the registering device and apply the proper correction for temperature and pressure for each hour.

The interior of the meter tube, especially the throat, should be kept clean. In the measurement of coke oven gas, naphthalene is apt to form in cool weather, and for such installations, a meter tube surrounded by a cast steam jacket at the inlet and throat portions is furnished. A live steam connection is made to this jacket through which the steam flows slowly and thus keeps the tube warm enough to prevent the formation of naphthalene. If very dirty gas is to be measured, it is not usually a difficult matter to place the meter tube on a by-pass line with blank flanges at each end, the arrangement being such that the gas can be shut off from the meter tube and the interior brushed out after removing the blank flanges.

One other important feature of the Venturi meter is its adaptability for change in measuring capacity. When the output of a gas plant has exceeded the maximum capacity of the Venturi meter as originally installed, one or two sections at the middle portion of the meter tube may be removed and a new

throat substituted. New dials and charts for the registering device make the alterations complete at a comparatively small expense, and the purchase of a new meter avoided.

THE ACTING CHAIRMAN: Is there any further discussion? Dr. Wing, will you briefly reply?

DR. WING: Mr. Chairman, it has been noted a few times that this is my paper. This is the Committee's paper. I might have said that the other members of the Committee are Mr. J. S. Kennedy, Mr. Carroll Miller and Mr. H. L. Underhill, and then we have been assisted by a number of other gentlemen who have given us valuable contributions and advice, and I take this opportunity to thank everybody for helping along the Committee's work. As to the points brought out in the discussion, there do not seem to be many things for me to answer; they answer themselves, or they were not questions addressed to me. Mr. Richardson made a few remarks about the Venturi meter. I meant to have emphasized, when I was speaking on that, that in using it you get quite a large differential pressure for reading pressure, and very little loss of pressure in the line. In these new meters that I have had a little experience with, the ratio of the line to the throat was 1 to 12, and where we were passing 250,000 or so, through a 10-in. throat the ratio of the loss of pressure to the differential pressure was 1 to 7. The loss of pressure was only about 0.3 in., and that makes it a very convenient method of getting a high differential, you see, with very little loss of line pressure. I think there is nothing more for me to say.

Mr. Hodges raised the question of the calibration of the electric thermometers in the Thomas meter and the possibility of error in the temperature difference.

The thermometer units are electrical resistance thermometers which are aged under severe temperature conditions before their installation in the meter, and their change relative to each other should be very slight. In order to guard against any errors that might occur from such source, arrangement is made for balancing the two thermometer units against each other



from the recording panel. This is done by breaking the heater current and allowing gas to flow through the units, thus bringing them to exactly the same temperature. The perfect balance of the thermometer units with respect to each other is indicated by the galvanometer needle which swings into its zero position. Should any slight change have occurred over a period of time, provision is made for quickly restoring the original balance of the units.

After the thermometer units have been balanced against each other, a temperature difference resistance is connected in series with the entrance thermometer which determines the temperature rise to be brought about in the gas by the heating unit. This temperature difference resistance is a small coil made in exactly the same manner as resistance units which have been used in standard electrical measuring instruments, such as Wheatstone Bridge testing sets, for a number of years. Inasmuch as their design is entirely simple and inasmuch as they are not directly exposed to the gas, there is no appreciable change whatever in their calibration over long periods of time.

Then, how are barometer variations provided for in the use of the Thomas meter? As explained in the paper and in Mr. Batten's discussion, the Thomas meter depends for its operation upon a physical property of the gas which does not vary with variations in pressure or temperature, and because of this fact, results are obtained from the Thomas meter dial directly in standard units at 30 in. barometer, 60° F., regardless of any variation in pressure.

MR. H. M. SPEAR (New York): I move that a vote of thanks be extended to Dr. Wing and the Committee for the very valuable report which they have submitted.

The motion was seconded and passed.

THE ACTING CHAIRMAN: If there is no objection, we will reopen the discussion upon Mr. Gilpin's paper on the testing of burners, and Mr. Bond has furnished a written discussion on that, which the Secretary will read.

The Secretary then read the remarks of Mr. Bond as printed on page 403.

THE ACTING CHAIRMAN: Gentlemen, you have heard the discussion; is there any action on it?

MR. J. H. TAUSSIG (Philadelphia): I move that the Manufacturing Section recommend that the Institute consider at to-morrow morning's meeting, the adoption of the Carpenter burner as a standard for the testing of gas for candle-power.

THE ACTING CHAIRMAN: Is the motion seconded?

A MEMBER: I second it.

THE ACTING CHAIRMAN: The motion has been duly made and seconded. Is there any discussion on this motion? All those in favor, will answer in the usual manner. (Ayes.) Opposed. (No response.) The motion is carried.

The next paper is "Purifier Installations," by Mr. C. E. Paige, of Malden, Mass.

## PURIFIER INSTALLATIONS.

### IMPORTANCE OF PURIFICATION.

The matter of the purification of illuminating gas is one which is necessarily being given constantly increasing attention. At present, it cannot be stated that purification methods have been, or are, capable of standardization. In many plants impurities are removed by methods which would be entirely impracticable in other plants.

In discussing the matter, it should be borne in mind that there are many conditions which determine how purification problems are to be solved in various gas works.

With the development of gas as a commercial possibility in the latter part of the eighteenth century, it was realized that if the industry were ever to reach proportions which would make it of the greatest possible value, the gas must be freed from foreign matter and impurities. In the earlier days, manufactured gas was chiefly produced by the destructive distillation of coal in retorts of one form or another. In those days, the disposition of the coke was about the only simple matter that presented itself to the gas manufacturer. Other residuals presented real problems. The economical utilization

of by-products had not yet been considered, and the recovery for commercial purposes of tar and ammonia, as well as the by-products of lesser importance, was entirely beyond the conception of the earlier gas manufacturers.

The problem of the purification of gas, as far as the removal of sulphur compounds was concerned, had not presented itself. It was not in fact until a comparatively few years ago that the matter of purification has required serious attention. There are many considerations which have compelled gas engineers to look into the problem of purification more closely within recent years. Every one is familiar with the unpleasant odor resulting from burning illuminating gas containing any very great quantity of ammonia or sulphur in its various compounds. From the service point of view, therefore, it becomes essential to keep these impurities in illuminating gas at a minimum.

The problem has become of increasing importance to most companies who from necessity are obliged to use coals containing a considerably greater quantity of sulphur than was the case a number of years ago. For many years, there has been a tendency toward a public regulation of the quality of gas, with the result that a great number of cities and a number of states now have specific laws or ordinances relating to the matter.

#### METHODS OF PURIFICATION.

When the necessity for purification of gas from sulphur compounds first became recognized, the use of slaked lime was common. This was satisfactory when low sulphur coals were used and where economy was of no particular importance. With the constantly decreasing price of gas to consumers, there has been a constantly increasing effort on the part of gas engineers to cut down production costs. The possibilities of making large savings in the cost of purification soon became apparent. Where originally purification costs were measured in terms of cents per 1,000 ft. of gas made, purification is not now considered economical unless it is reduced to tenths of cents per 1,000 ft.

The use of lime for purification has been superseded quite

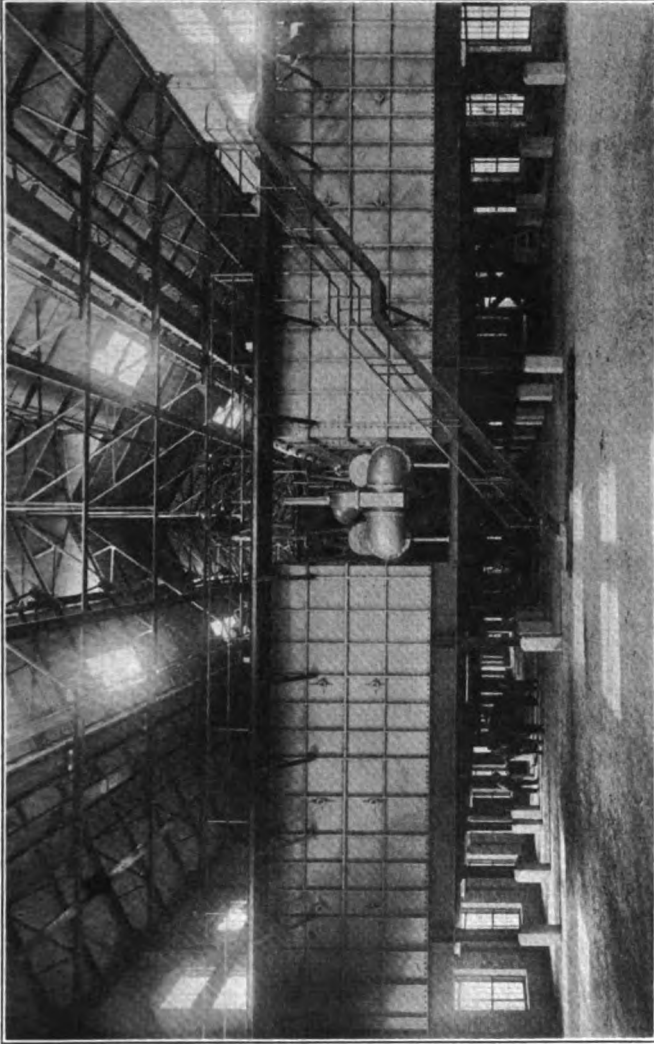


Fig. 1. --(No. 4) Cast iron boxes.

generally by the use of oxide of iron and various natural ores.  
There is a strong belief on the part of some engineers that

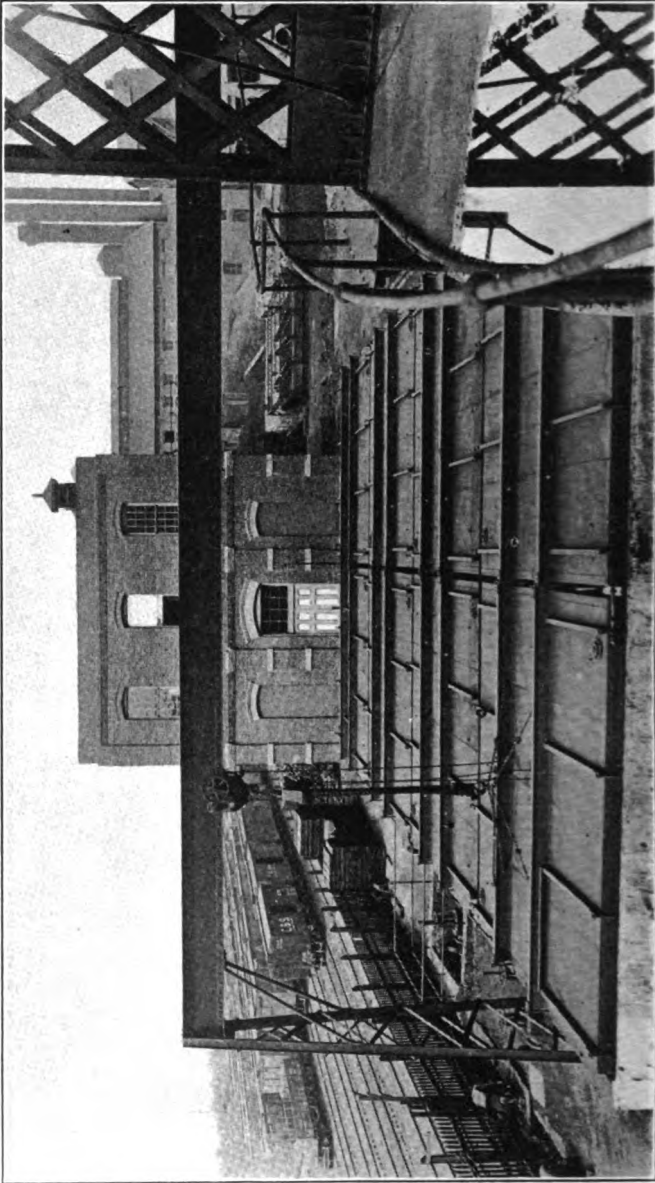


Fig. 2.—(No. 8) Concrete boxes.

sulphur compounds will be removed ultimately by some form of washing process. Mr. H. M. Papst, of Portland, Oregon, describes, in his paper on "The Removal of Organic Sulphur in Gas," read before the American Gas Institute in 1910, a method of breaking down the sulphur compounds by heating the crude gas in shells filled with checker brick. After this treatment, the impurities chiefly in the form of  $H_2S$  are easily and economically removed. In the same year, Mr. M. E. Mueller read a paper on the extraction of cyanogen from coal gas at the Astoria Works. Perhaps the most interesting contribution to the purification problem during the present year, is the paper read by Mr. Charles Carpenter before the Institution of Gas Engineers in Liverpool last June, on "Purification by Heat: A Century's Progress and Lessons." In this paper the development of heat purification possibilities is thoroughly discussed.

#### PURIFIER INSTALLATIONS.

Many papers have been written on the various methods of accomplishing the economical purification of gas. We are, in the present discussion, concerned not so much with the theory of the removal of impurities, our object being that of "Purifier Installations."

When purifier installations began to be important items in the cost of a gas plant, boxes built of cast iron were commonly used. These boxes were usually built with sheet iron covers reinforced across their area with I beams or angle irons. Boxes were usually placed 4 in a set and were controlled from one central point by a center seal valve. Covers were of the wet seal type, the sides of the cover dipping into a channel filled with water on all four sides of the box.

The center seal valve answered its purpose very well for a number of years, but its use has been largely discontinued in purifier equipments more recently installed, because of the difficulty in keeping the joints sufficiently gas tight to prevent the gas by-passing from one section to another. Perhaps a still greater objection to this device is that with the ordinary

center seal system, only 3 boxes out of 4 can be kept in operation, one always being "out" for cleaning. As a result only three-fourths of the total purifying capacity is effectively at

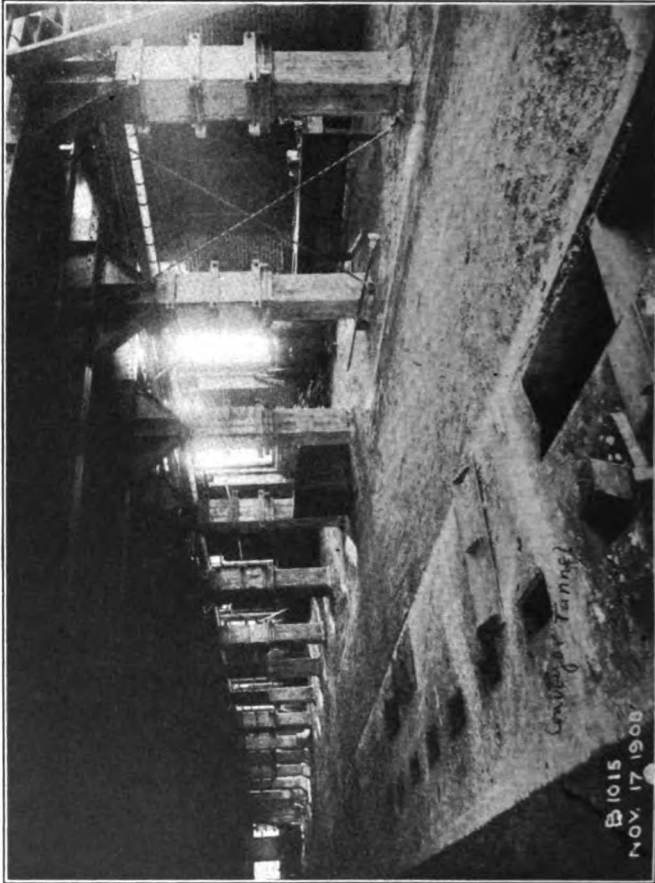


Fig. 3.—(No. 13-b) Oxide conveyor tunnel in one of the large purifier installations.

work. The gate valve system permits of keeping all 4 boxes in operation except for the time of emptying and refilling. In this way maximum purification is accomplished and the largest possible proportion of the investment is kept actively in use.

While there is a hope that some form of liquid purification

will ultimately be employed for removing at least a large part of the sulphur, yet from present developments there is noth-

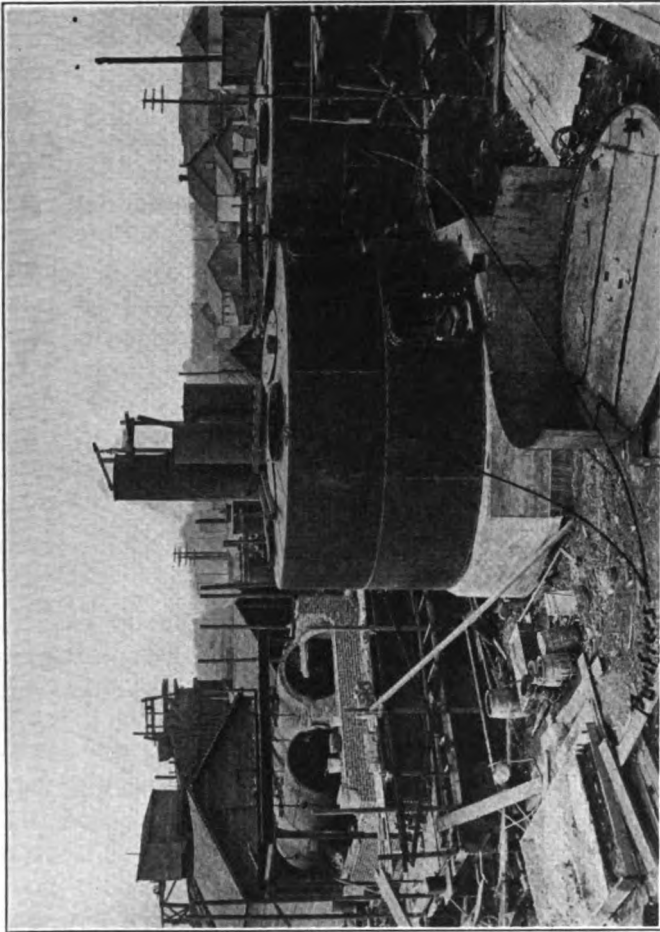


Fig. 4.—(No. 14-a) Outside steel purifiers under construction. Note openings for emptying and filling boxes.

ing to show that oxide or dry purification will be entirely superseded.

The treatment of gas in all its stages of purification is essentially a question of chemistry, and anyone who takes the



position that any present process is final, exhibits a lack of imagination.

Sulphur exists in gas in various forms, all of which are objectionable, and oxide removes effectively only one of them. If a process should be discovered which would absorb all forms, and convert any one form into some other, which might readily be absorbed by a liquid in the same manner in which ammonia is absorbed, then if such process were itself simple, we would have very nearly an ideal method, because liquid and gas can be brought into common contact with small apparatus and at minimum expense.

As far as these processes have at present been developed, they are dependent upon such delicate balances not yet reduced to automatic control, that we find skill necessary for their proper operation, which is lacking in the ordinary works.

We find purifiers of all types and descriptions throughout this country,—cast iron, steel, rectangular and circular, inside and outside of buildings, and in the West we find purifiers made of wood. Unquestionably the local conditions determine largely the type of installation at any good plant.

#### MALDEN INSTALLATION.

Some time ago the purifying capacity at Malden required extension. At that time the plant had an average output throughout the year of 1,700,000 cubic feet per day, of which, 900,000 cubic feet was coal gas and 800,000 cubic feet was water gas. The purifying equipment consisted of two sets of apparatus. There were four boxes, 24 ft. x 20 ft. x 3 ft. deep in one set. These boxes were connected with 16-in. pipes, and were operated by a center seal. These boxes were rated at approximately 750,000 cu. ft. per day, but frequently there were hours when double this quantity of gas had to be passed to keep the necessary margin of storage.

The other installation consisted of five cast iron boxes. 25 ft. x 25 ft. x 5 ft. 10 in. deep. These boxes were equipped with 20-in. connections, and four of them were controlled by water valves. The fifth box was designed as a lime box, and

had ordinary gate valve connections. These boxes were of the dry lute type, while the set first mentioned were of the ordinary wet seal construction. In each case the boxes were arranged in a row. In the case of the smaller installation, the oxide is raised to the upper floor by a hydraulic elevator, and from there wheeled to the various boxes. This is an expensive way of handling material. A bucket elevator with a corkscrew conveyor has been tried, but it was found that this conveyor pulverized the oxide to such an extent that back pressure troubles were very frequent. Its use was, therefore, discontinued.

In the larger installation, a hydraulic elevator is supplemented by a conveyor installation. Throughout the entire length of the series, about two feet below the floor level on the lower floor, there is a belt on which the purifying material may be dumped. This feeds into a bucket conveyor, which lifts the oxide to a distributing belt above the boxes. This belt is equipped with a movable dump arrangement. This apparatus is satisfactory in using manufactured oxide, but in the use of natural ore, we have had much trouble with the material clinging to the belt, in spite of brushes which have been used.

Our principal consideration in planning for an extension of equipment, is ground space and investment. We had a definite area in which boxes could be located; we wished to utilize this to the greatest possible advantage as far as maximum purifying capacity was concerned.

In working out the purifying capacities, we used the formula given in the Catechism for Gas Engineers. This necessarily is more or less of an approximation, because the condition of the oxide used and the sulphur content of the gas, are variable factors which must be included in the consideration.

In deciding upon our form of installation, we reasoned as follows: There are many types of boxes, but we are looking for the installation best suited to our conditions. Essentially the purifying box is only a container of material. Other

things being equal, it would be efficient according to its area and depth ; therefore, it would be equally efficient whether built of steel, cast iron, wood or concrete, circular or rectangular.

The absorbing effect of the oxide being considerably influenced by temperature, it is important that this be maintainable, and not of consequence otherwise, whether the boxes be located inside or outside of a building, or whether heated from the inside or outside, or not heated at all, if the gas is itself of such temperature as will maintain the temperature of the oxide.

We have conditions of investment to consider. Everything else being equal, outside purifiers have the advantage, by reason of requiring no elaborate building with heavy fixed charges. Again, other things being equal, we recognize the advantage in outside purifiers as being safer to operate, as changes are made in the open air and there is much less danger of asphyxiation.

The question of design is more complex. First, the gas passes through a loose spongy material ; we know that it is important that it pass through the entire area of this material ; we also know the importance of having this material distributed uniformly so that there will be equal resistance, resulting in an equal rate of flow through the entire area. We see at once that if the material is to be loaded into the box from a single point, such as an elevator spout, there is necessarily a greater tendency to compact or densify the material that lies immediately under the spout, and according to the men who distribute the oxide from this point of discharge, there may be a greater or lesser density over the entire area of the box. It becomes important, therefore, to so design the box that the distribution of oxide will insure equal density, with the least requirement for supervision of the workmen.

For the above reasons, we believe that as much as possible of the entire top of the box should be removable, as otherwise equal distribution of the material becomes difficult. If circular purifiers are used, the cover must be as great in diameter as possible, to facilitate even distribution of the material.

Rectangular steel boxes present the difficulty of maintaining rigid sides that will not bulge in spots under pressure and thus let the gas slip up past the oxide. All steel construction most readily lends itself economically to circular forms, so that the tensile strength of the metal may be employed to resist the gas pressure and maintain a rigidity of wall. Cast iron is expensive, particularly for high pressure, and where exposed to cold and local temperature changes, is liable to crack. Cast iron has greater permanency, and steel has lesser life, in the presence of oxide.

The question of materials of construction is, therefore, more particularly one of expediency. If we wish to avoid the construction of a building, we must consider some form of insulation for the boxes. We wish to take advantage of the natural insulation of the ground, but we could not very well place metal structures below the ground level. This led us to the consideration of concrete.

The first point that occurred to us in connection with the matter was the question of how often it would be necessary to change the material in the boxes and the most economical manner in which to accomplish this shift. If the changes must be made frequently, we felt that some economical means of accomplishing this would be necessary. Such a condition would be presented with a high sulphur coal.

On the other hand, if the oxide handling apparatus would be used only six or eight times a year, the maintenance and depreciation would probably more than offset the saving in labor for doing the same work manually. For the present, therefore, we decided that the best way to remove the oxide would be by shovelling, and that the top edge of the box should be placed only far enough above the surface of the ground so that it could be emptied by shovels and filled by wheelbarrows with the minimum change in elevation.

In order to attain the greatest possible purifying capacity for a given area, we concluded that it would be wise to make these boxes double depth, that is to say, so deep that they would require two stage shovelling for unloading. We felt

that this would be economical in the long run because our boxes would be of sufficient capacity so that frequent changes would be unnecessary.

Another very important consideration in deciding on types of installations are the connections. With a box placed underneath the ground, the connections take up a minimum of surface area, and also have the advantage of considerable natural insulation.

The next question then naturally arises as to what objection there could be to concrete. We have been led to believe that concrete, properly mixed, becomes harder and harder as time goes on. The only serious objection that we can find is the possibility of the boxes leaking. We know that to make concrete water tight, the material must be carefully prepared and carefully placed. We know that to make concrete air tight is an even more serious problem,—to make it gas tight presents a problem which we know requires the greatest possible care, but we also know that it has been done. With concrete boxes placed in the ground, we felt that our risks from corrosion or bulging were minimized, and if, for any reason, there should be any cracking due to settlement, the cracks might be effectively patched with cement. Heavy concrete walls partly buried in the ground furnish a natural insulation which is valuable, and the heat losses cannot be serious except with the exposed top.

Then there is the question of safety. Serious accidents have occurred with various types of boxes sheltered in houses, these accidents taking the form of asphyxiation and explosion. It is fair to assume that there is just as great liability of accident in any one type of box as another, but the resultant dangers are reduced where the box is in the open.

We finally concluded to build concrete boxes, and four of these boxes, each 25 ft. x 30 ft. x 10 ft. deep, gave us an installation in our available area with sufficient room on the side of the boxes for handling the oxide during the revivification of material. These boxes were equipped with 20-in. connections and with a direct valve gate system. The walls of each

box are 2 ft. thick, except where the wall of one box adjoins the wall of another, and in this case, the walls are 12 in. thick with a pitch-filled space of  $\frac{1}{2}$  in. between them.

It was found on excavation that the soil was coarse sand giving us a very good bottom for the concrete. The bottom of the boxes are 9 in. thick. We concluded that, although somewhat more expensive, it would be wise to have the boxes all cast at one time; in other words, to make a monolith as far as possible.

When the forming was completed, concreting was started and kept up continually until one box was completely finished. To secure a dense concrete, a mixture of 1-3-5 was used. To insure safety at maximum capacity, a pressure of two pounds per sq. in. was agreed upon for test purposes. This pressure was to be applied at sundown when there would be a minimum contraction or expansion effect resulting from heat. The pressure was to be sustained for a half hour, with a loss of not more than one-eighth of a pound.

To insure safety, the covers of the boxes were reinforced with 15-in. I beams. These covers were of the dry lute type, the gasket coming down on an I beam imbedded in the concrete.

The first tests on the boxes were disappointing, as we found it difficult to hold up any pressure at all. We then directed our effort toward making one box tight before undertaking any experiments on the remaining number. Various forms of water-proofing compounds were used without success. Finally the surface of concrete inside the box was chipped, a  $\frac{3}{4}$ -in. layer of practically neat cement was applied with trowels, and after this had set up for a time, a coating of pitch was put on.

These boxes were to be used for water gas purification; we knew that the oils in the water gas would probably cut the pitch, but we felt that gradually the pitch coating would be replaced by a coating of water gas tar and oil which might penetrate more deeply into the concrete, but which would insure greater tightness with age.

This box passed the test very successfully. The other boxes were treated in the same way, except for the coating of

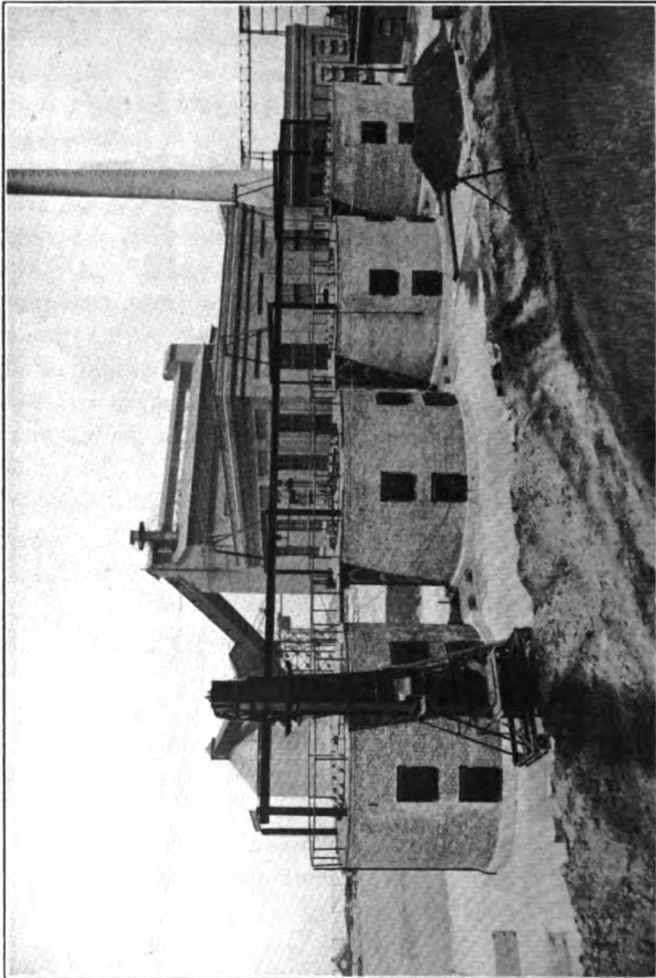


Fig. 5.—(No. 16-a) Completed installation. Note oxide elevator. The sides of these boxes are insulated with a 9-inch brick wall kept 2 inches from the steel. Granular ring is filled with ground cork. Covers are insulated with slab asbestos.

pitch, which was not applied. Gas was turned on and the boxes have been in continuous use for more than a year. They have been opened up for examination from time to time, and

we find that our theory is correct. The inside surfaces of the boxes have been thoroughly coated with water gas tar and oil, with the result that these surfaces now present a dull black appearance, but we are unable to observe any leakage whatever.

In figuring up the costs of purifying capacity, it is difficult to establish a unit of comparison, as there are so many considerations which enter into the matter. In comparing investment costs, it seems that the fairest unit to take would be the cubic feet of oxide capacity. Calculating the cubical contents of these boxes and allowing 20 per cent. for beams, trays, ducts, etc., we find that the actual costs of the installation per cubic foot of net oxide capacity is slightly more than 84 cents.

These boxes are equipped with four layers of trays and with inlet and outlet ducts, so arranged that the gas may enter at the middle and go up and down through the oxide, or may enter at the top and bottom and leave at the middle, or may enter through the top or bottom, leaving the box at the point opposite the point of admission.

#### QUESTIONNAIRE ON PURIFIER INSTALLATIONS.

While the above information applies specifically to the recent installation at Malden, it is felt that a comparison of other types of boxes might be interesting. Accordingly a series of questions was sent out to a great number of gas companies, and many replies have been received. The companies which have furnished information in connection with these comparisons are identified only by number, as are also the photographs shown in connection with the paper.

Some of the questions which were asked, with typical answers, were as follows :

Are boxes inside or outside of buildings	Steel, iron or concrete	Circular or rectangular
1. Inside	Cast iron	Rectangular
2a. Inside	Cast iron	Square
2b. Outside	Steel	Square
3. Outside	W. G. steel	Circular
Outside	C. G. steel	Rectangular
4. Inside	Cast iron	Rectangular



Are boxes inside or outside of buildings	Steel, iron or concrete	Circular or rectangular
5. Inside	Cast iron	Rectangular
6. Inside	Cast iron	Rectangular
7. Outside	Steel	Circular
8. 4 Inside	Cast iron	Rectangular
2 Outside	Concrete & steel	Rectangular
9. Inside	Cast iron	Rectangular
Outside	Steel	Circular
10. Inside	Cast iron	Rectangular
13. Inside	Cast iron	Rectangular
14. Outside	Steel	Circular
16. Outside	Steel	Circular
17. 3 Inside	Cast iron	Rectangular
1 Outside	Steel	Circular
19. Outside	Steel	Circular
20. Inside	Cast iron	Square
25. Inside	Steel	Circular
41. Outside	Concrete	Square

	Number of boxes and inside dimensions	If steel or iron, thickness of metal	If concrete, thickness of walls
1.	4-8' x 5' x 3'	$\frac{3}{8}$ "	
2a.	24-40' x 40' x 8'2"	$\frac{3}{8}$ " & $\frac{7}{8}$ "	
2b.	8-34' x 34' x 13'3"	$\frac{1}{16}$ " & $\frac{3}{8}$ "	
3.	3-21' diam. x 11' deep		
	4-30' x 20' x 4'		
4.	8-30' x 36' x 8'	$\frac{7}{8}$ "	
	4-21' x 35' x 12'	—	
5.	4-16' 10" x 12' 10" x 3' 10"		
6.	4-20' x 35' x 10'	$\frac{3}{4}$ "	
	4-23' x 30' x 7'6"	$\frac{3}{8}$ "	
7.	3-21' diam. x 11'6" deep	$\frac{5}{16}$ "	
8.	4-25' x 20" x 6'	1" & $\frac{3}{8}$ "	
	2-40' x 40' x 16'		16" & 18" Exp. metal reinf.
9.	20' x 20' x 7'	$\frac{3}{8}$ "	
	21' x 11'	$\frac{5}{16}$ "	
10.	20' x 20' x 11'	1" & 1 $\frac{1}{4}$ "	
13.	40' x 40' x 10'	1"	
14.	25' x 12'	$\frac{1}{4}$ "	
16.	23' x 12'	$\frac{1}{4}$ "	
17.	2-12' x 12' x 5'	1"	
	1-20' x 12' x 12'	1"	
	1-21' x 11'6"	$\frac{1}{4}$ "	
19.	4-17'6" x 11'6"	$\frac{3}{8}$ "	
20.	4-35' x 35' x 12'	$\frac{1}{2}$ "	
25.	35' x 9'	$\frac{1}{4}$ "	
41.	4-25' x 25' x 8'		2'6" sides-1'8" bottom

Q. Give description of purifying box cover.

- 2a. Crowned one way and stiffened by 13 internal angle iron trusses, 28 in. deep at center, holding down lugs being secured on the top of the ends



Figs. 6 and 7.—(No. 19) Outside steel boxes.

of 7 of these trusses. Holding down device consists of a parallel bar fastened to steel supporting structure, and provided at top with an eccentric roller, operated by hand lever.

36 in. water seal equipment provided with 32 in. break-seal boxes ahead of purifiers.

- 2b. Crowned one way and stiffened with 5 internal lattice trusses, each 3 ft. 3 in. deep at center. Eleven holding down lugs on each side of cover, making 44 per box; hinged bolts with nuts used to secure cover.
- 3. Water gas boxes, circular flat cover, reinforced with radial I beams; square asbestos gasket used, which is satisfactory.
- 14. Covers all steel. Five 4 ft. diameter manholes. Dry seal with red lead for gasket, which is satisfactory.
- 16a. Steel circular cover 15 ft. in diameter;  $\frac{1}{4}$  in. steel plates riveted on to angles inside of cover. Asbestos gaskets used, but are not very satisfactory. Braided hemp to be tried.
- 22. Steel boxes, dry seal; bolted hatch of the marine or navy type. Cast iron boxes converted wet seal to dry seal by dispensing with seal and bolting cover down.
- 25a. The cover to these boxes is in two parts; a movable cover 20 ft. in diameter, which is built with an angle iron rim, consisting of a flat top, supported on radial built-up girders on the outside. At the center, these are connected by a circular plate, and on the outside there is a carrier for the holding-down screws. The fixed top is in the form of a frustrum of a cone, the inside edge of which is fastened to a Z-bar ring, on which the movable cover rests.
- 25b. Cover built for dry seal.
- 25c. Up to the present time, the gaskets have been rubber, and have been in use about 9 years. They have deteriorated to such an extent that they will have to be replaced, and when we make this replacement, it will be with special asbestos gaskets.

- 32a. Covers are made of  $3/16$  in. charcoal iron, and are designed for 24 in. water seal.
- 32b. The top plate of cover is made of No. 10 steel, covering the entire area of the box. Plate is strengthened with 6 stiffeners, each composed of 2 angles with a web plate between them. The sides are channels of sufficient depth to make the necessary joints at corners with end plates, and are provided with flanges for bolting down. The end plates are provided with angles used as stiffeners, and flanges for bolting down. An internal angle encircles the top of the cover for holding fast the sides and top; ties are provided on interior to hold cover in shape.
- Dry seal covers with  $3/4$  in. square asbestos packing, which is satisfactory. These boxes will operate at a pressure of 34 in. of water.
36. The top is permanently fixed with 4 round doors 5 ft. in diameter. There are 2 rectangular doors in the side of the box. The doors are dry sealed with cotton packing and red lead, which is perfectly satisfactory. The boxes were tested to 30 lbs. pressure, but are being operated at less than 1 lb.
37. Covers are made of steel, and built for dry seal, with  $5/8$  in. asbestos gaskets with interwoven copper mesh. There are 2 blow-offs with test cocks bolted to top of each cover.

Q. (a) how many layers of purifier material are used? (b) In what manner are trays supported? (c) Does gas pass up through all the material, or are the boxes designed for divided flow? (d) Are connections designed for reversing the flow of gas?

In practically all cases, the number of layers depends directly upon the depth of the boxes. The minimum layer of

oxide reported is a little less than 2 ft.; the maximum is about 4 ft.

In the smaller installations, particularly those of the earlier type, the gas passes up through the oxide without any means for reversing the flow. In the larger boxes, the flow is divided, and in many cases, connections are arranged so that the direction of the flow of gas may be reversed if necessary.

Q. Describe method of revivification of material.

Practically the same method is used in all of the companies reporting. Very few use any machinery in connection with oxide handling during revivification. The oxide is usually piled from 12 in. to 30 in. deep, and is turned as frequently as conditions make necessary.

In a few of the plants, oxide is being reclaimed by burning after it has absorbed its complement of sulphur once. This method is worked out very satisfactorily in one or two instances. In some cases, however, it has been tried without very good results.

Q. Are boxes loaded by machinery or by hand?

In practically all installations where the boxes are 25 ft. square or larger, there is apparatus for loading the boxes, and in nearly all installations where boxes are placed above floor level, dumps are provided through which the boxes may be unloaded.

Q. If boxes are out of doors, describe method of protection, if any.

- 2b. The sides of the boxes are encased in hollow brick walls  $4\frac{1}{2}$  in. thick, the covers are lined with horizontal wooden false ceilings, and the above ground gas mains are lagged with an asbestos hair felt, roofing felt and canvas covering about  $2\frac{1}{2}$  in. thick. Recently one line of  $1\frac{1}{2}$  in. steam pipe has been put in under each of the 3 layers close to the inside walls of the box, making 3 squares each of 130 linear ft. of  $1\frac{1}{2}$  in. pipe connected in series, in each box.

The idea is to use enough steam in each of the box heating coils to prevent loss in temperature of the gas while passing through. The condensed steam is returned to open heater in boiler house.

8. Steam coils in covers of outside boxes.
9. Boxes are lagged and are surrounded with a 4 in. hollow brick wall, leaving an air space.
17. The outside box is surrounded by brick wall, consisting of one layer of brick.
19. Box kept well painted.
41. Concrete boxes. Earth banked up around sides.

Q. In view of recent developments, would you advocate increasing capacity, if it were necessary, by the same type of installation which you now have?

Almost without exception the companies report that they would use the same form of installation as they now use, but many would eliminate the center seal and use a valve system, and would also convert wet seal boxes into dry seal boxes.

Q. What is the approximate cost of a box per cubic foot of net oxide capacity (allowing for displacement of tray supports, ducts, etc.) with and without building?

Concrete boxes vary from 85 cents to slightly over \$1.00.

Outside steel boxes vary from \$1.00 to \$1.25.

Inside cast iron boxes without building vary from \$1.25 to \$2.25; with building they vary from \$2.30 to \$3.40.

Q. On what basis is depreciation figured.

In one case boxes are made of copper steel, containing  $\frac{1}{2}$  per cent. copper, and it is expected that the depreciation will be very small.

In some cases no depreciation is figured, as the matter is taken care of under maintenance. The average depreciation is about 5 per cent.

Q. Do you have state or municipal restrictions regarding purity of gas?

Practically every company reporting has either state or municipal restrictions and in some cases both.

Q. Do you use purifying material of your own manufacture, or do you buy the material outside?

The majority of companies make their own material, the remainder buy part of their material outside.

Q. Are your boxes equipped with perforated steam or water pipes to prevent fire or explosion when the box is to be opened? What arrangement have you for a purpose of this kind? Can you suggest any accident prevention methods which can, or should, be adopted in the construction or operation of boxes?

- 2a. Steam is introduced directly into the box below each of the two layers for  $1\frac{1}{2}$  hours after inlet and outlet valves have been shut and cap on cover removed. High pressure steam is used through one  $\frac{3}{4}$  in. connection under lower layer and two between the two layers. Do not consider introduction of steam in this manner to be of much service, and there is some question if it does not tend to cause local heating when material is dumped.

After valve boxes are closed, it might be advisable to displace the gas in the box with an inert gas, such as boiler flue gas, same being cooled before being pumped into box.

6. Steam jets into sides of boxes.
8. Perforated spray pipes for steam or water.

Use no lights about purifying equipment except electric lamps enclosed in marine globes. Have an iron clad rule prohibiting lights (except as described) or fire within 100 ft. of any purifying box. Prohibit smoking within same distance. Have purifying equipment in charge of a steady, careful man. Have usual fire fighting material handy, as for other parts of works. No other precautions are necessary, except those used wherever gas is handled. Accidents are chiefly due to carelessness or laxity of rules.

- 13b. A  $\frac{1}{2}$  in. high pressure steam inlet under each oxide layer in a box. A copious supply of steam on opening an active box filled with oxide.
- 14. Water hydrants adjacent to changing doors and fire holes.
- 16a. Does not feel that there is much fire risk in outside boxes, unless an attempt is made to revive the oxide in place.
- 22. Accidents are prevented by never allowing air in box from bottom. Fire hose is laid out ready to protect top of oxide in box. Dumping doors on bottom of box should have air tight connections extending through oxide, thereby preventing any air from circulating underneath oxide. Box to be dumped to be cut out one day before dumping.
- 23. There are steam connections to inside of boxes.
- 29. A single steam connection is tapped into bottom of box. No perforated steam or water pipes. Besides the above, there is a fire hose connected to water supply adjacent to each box. There are no exposed lights. Electric lights are used; the wire is placed in rigid conduits and marine globes are used with the lamps.

To prevent asphyxiation accidents, building should be amply ventilated and sufficient and unobstructed exit facilities be provided. Also, first aid appliances, oxygen tank, pulmotors, etc., should be readily accessible.

When revivification in the boxes is practised, tubes should be inserted in the oxide at locations distributed throughout the area for the insertion of thermometers, and the regular observation of same while revivification is in process, in order to detect in time a dangerous rise in temperature in any portion of the bed.



- 32a. No steam or water jets. Fire protection consists of hose connections from works fire system.  
 The following general suggestions are made:  
 Plenty of light from windows in the daytime, and vapor-proof electric lights at night.  
 Good ventilation. If boxes are of the cheese box type, sufficient number of roomy doors on the sides of the boxes.  
 Devices to prevent men's hands and feet from being caught and bruised by moving parts of cover lifting carriage.  
 Substantial runways for wheelbarrows.  
 Good efficient elevator safety gates.
38. Boxes are provided with cast iron, sectional, flanged chutes, with a cover on top of each extending up through the material from bottom openings.

#### UNUSUAL INSTALLATIONS.

We find in many cases that unusual conditions have obliged engineers to make rather unusual installations. For instance, in one plant there are 2 purifying houses, one erected in 1887 and the other in 1901. The former contains 8 20 ft. x 24 ft. boxes on 2 floors, and the latter 2 30 ft. x 30 ft. boxes. The unusual feature of this plant is that the 20 ft. x 24 ft. boxes are located on the second and third floors of the building, 4 boxes to each floor, and one set directly over the other. This arrangement was to economize space. It requires an expensive type of building with abnormally heavy walls.

In California, we find that another type of box is in use which is interesting. In 1904, it was decided to extend the purifying capacity at Oakland, California. It occurred to Mr. E. C. Jones that a circular wooden tank, made of redwood staves, 2 in. thick, with a wooden bottom and top made of the same material, and fastened into the staves by chimes, the same as a barrel head, would admirably answer the purpose for an outdoor purifier in a climate where the temperature

never goes below 40 deg. and seldom above 85 deg. The only difficulty was to obtain a redwood tank that would not dry up

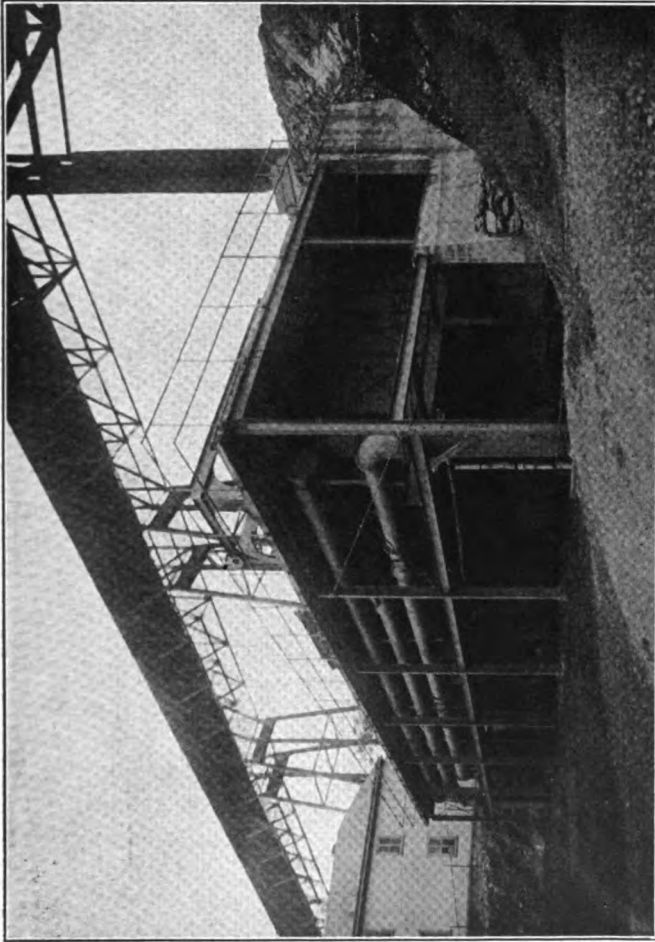


Fig. 8.—(No. 37) Note angle of bank and character of soil.

and fall to pieces. He found that the Pacific Tank Company, of San Francisco, constructed oil tanks of redwood staves, with grooves running lengthwise of the staves, and a series of

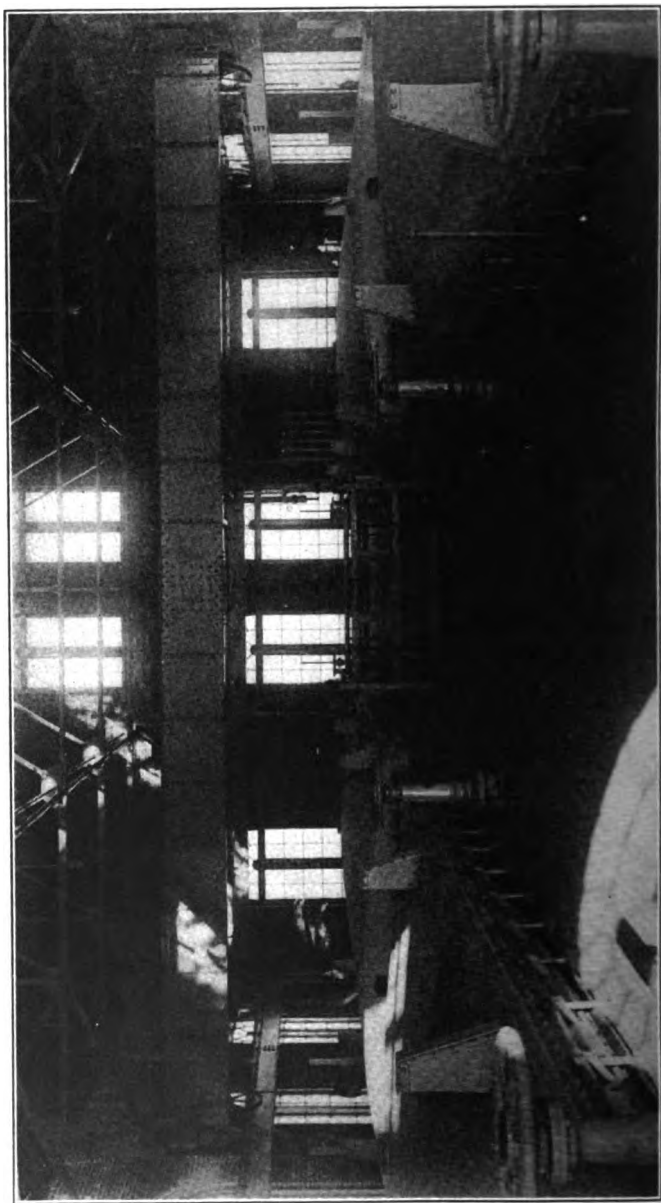


Fig. 9.—(No. 38) Note dry lute construction and also large crane for handling covers.

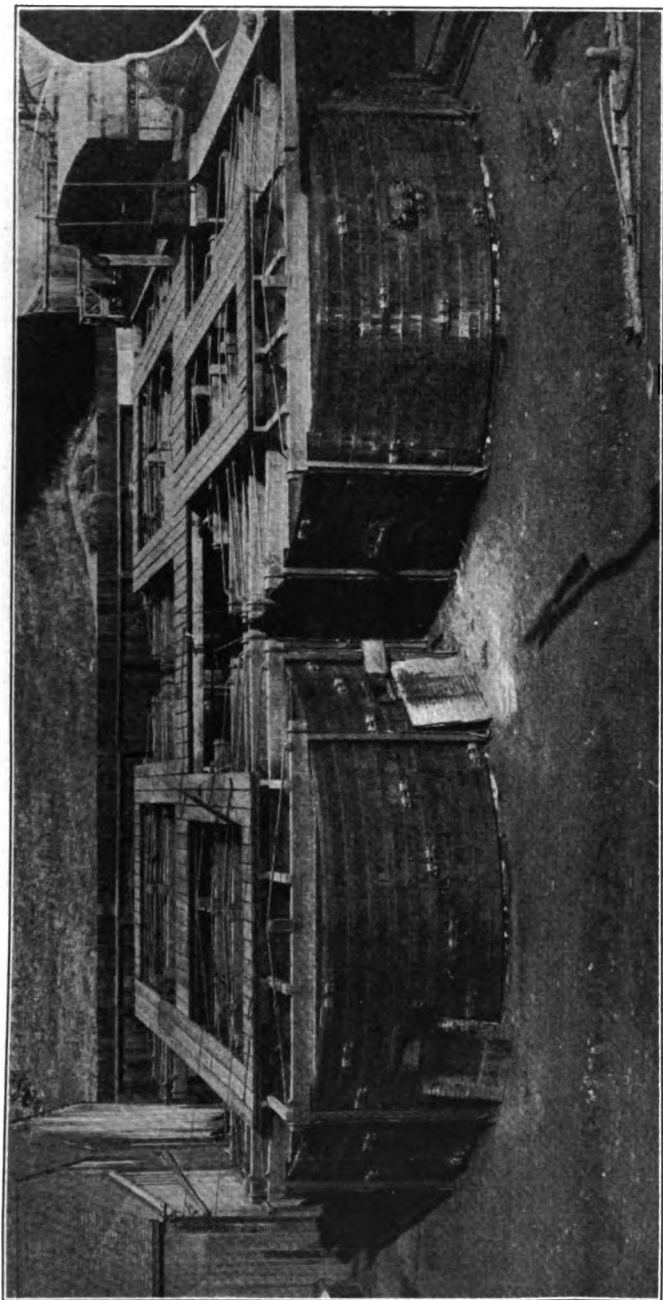


Fig. 10.—(No. 43) Four Jones' wooden purifiers 30' x 7' 10".

holes bored through the staves crosswise. These holes and grooves all terminated at a common inlet at the top of the tank just above the chimes, and by filling the top of the tank with water to a depth of about 2 in., a circulation of water takes place continually through all the staves. The water is then permitted to drop slowly on the top of the tank, and overflows

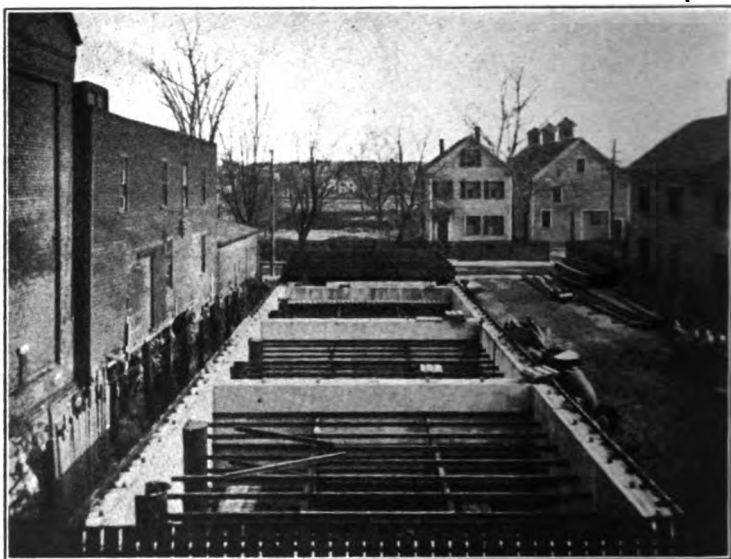


Fig. 11.—Concrete purifiers at Malden.

into a drain at the bottom. This keeps the staves water soaked and swollen in place, and the tank itself, constructed of California redwood, will practically last forever.

Their first boxes were 30 ft. in diameter and 9 ft. deep, and were surrounded by flat hoops. These were afterwards changed to round steel hoops to avoid rusting and to facilitate painting. The tops of the boxes are heavily trussed and these trusses are anchored to railroad iron set in a concrete founda-

tion. This is to withstand the great pressure on the cover due to the large area. The first set of boxes were coated on the inside with paraffin, and then lined with canvas prepared with

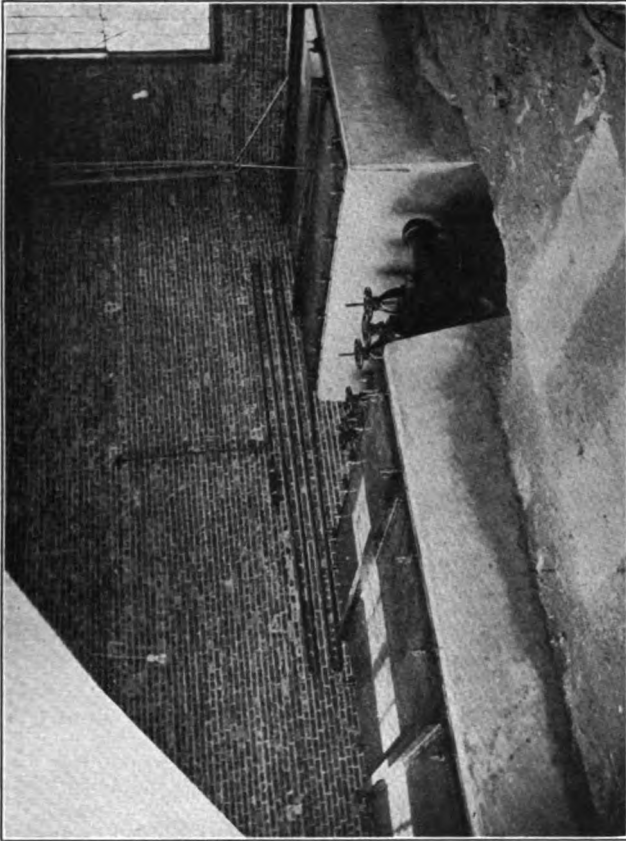


Fig. 12.—(No. 11-b) One of the earlier installations of concrete boxes.

boiled linseed oil similar to the preparation of balloon cloth. It was afterwards found that this was unnecessary, and that the redwood tanks were absolutely gas tight without any coating.

In closing, the writer wishes to express his thanks to vari-

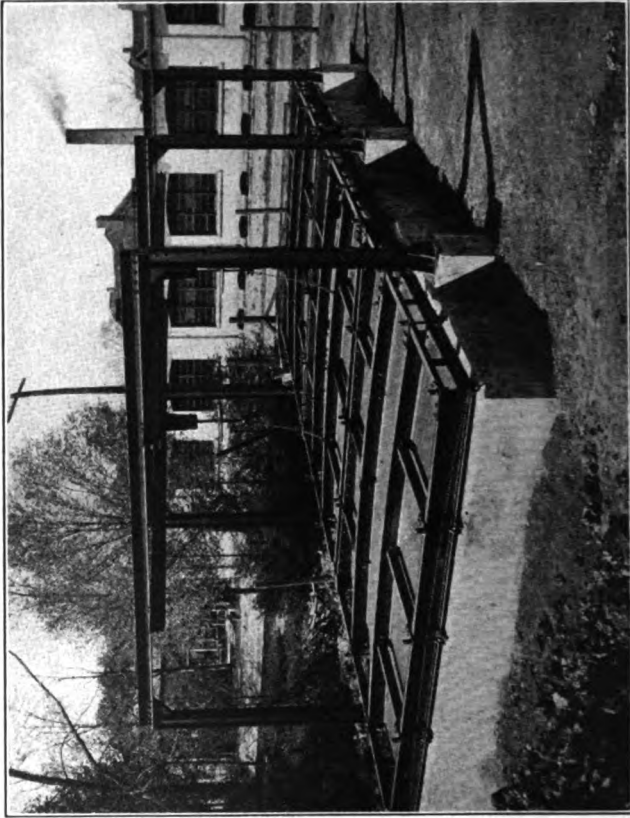


Fig. 13.—(No. 11-b) Typical installation of concrete boxes for small plant.

ous gas men throughout the country who have contributed information in connection with this paper.

(Mr. Paige read an abstract of his paper.)

THE ACTING CHAIRMAN: Mr. Paige's very interesting paper is now open for discussion. Is there any discussion on this paper?

MR. E. H. EARNSHAW (Newark): Mr. Chairman, I have been much interested in Mr. Paige's paper, and prepared a

short discussion, which is not a discussion, really, but something of an addition to it. Mr. Paige described his method of increasing capacity by putting in concrete boxes, and I have described the method adopted by the Public Service Gas Company to meet conditions requiring additional capacity. Mr. Paige has given us a good description of the purifiers at Malden and his reasons for selecting the type of installations.

The Public Service Gas Company has adopted for several of its plants a combined system of cast iron boxes housed, and circular steel boxes outside, which differs in some details from any of the installations described by Mr. Paige. A brief description of this system may be of interest.

The original purifier equipment at the West End Gas Works, in Jersey City, consisted of four cast iron boxes housed in a brick building, each box being 36 by 36 by 6 ft. deep. About 5,000 bushels of oxide was the charge for each box, in two layers 30 in. deep. The boxes were arranged in a square, and a centrally placed vertical elevator with revolving discharge chute, together with ample dumping doors in the bottoms of the boxes, made it possible to handle the oxide with considerable economy of labor.

In 1909, the output of the works reached the normal maximum of 7,000,000 per day, for which the purifying plant was designed, and it became necessary to put in additional apparatus.

In our climate, filling and emptying outside unprotected purifying boxes in winter, is anything but cheap or pleasant, and in considering the matter of increased capacity, it was our desire to retain the benefits of purifiers housed in a warm building, while keeping the capital investment down to the lowest point.

We finally decided to build boxes without a surrounding house, and to connect these outside boxes with those inside the house in such a manner that two inside boxes would work in series with two outside boxes. As the foul gas always passes through one or two inside boxes before reaching the



outside boxes, the latter become in reality "catch boxes," and the quantity of hydrogen sulphide remaining in the gas reaching them, is relatively so small that the oxide can be revived in place, without difficulty or danger.

The equipment of the catch boxes includes apparatus for furnishing air blast, and the boxes are revived in rotation, practically each one every four days. This keeps the oxide in the catch boxes always active and enables us to get very full duty out of the boxes inside the house.

The experience of four years has shown that the outside boxes do not need to be refilled oftener than once a year. We have made it a practice to examine the boxes every year in the late summer, so as to be ready for the heavy sendout of the fall and winter, but usually it has only been necessary to put new oxide in one layer.

We will this year reach an average make through this system of purifiers of about 11,000,000 per day, with a maximum of over 14,000,000. The average yearly cost of purifying labor, which includes emptying and refilling boxes and revivifying oxide, has never exceeded, and is usually less than, 0.10 cents per 1,000.

The water seals on the inside boxes limit the pressure we can use to force gas through the boxes, and to pass gas at any rate over about 13,000,000 per day, it is necessary to put all the inside boxes on singly, so that the gas is divided into four streams before it reaches the catch boxes.

We believe that by changing the water seals to dry lutes, so that the initial pressure can be raised to 40 in. or more, the installation will have a normal purifying capacity of about 16,000,000 per day, with an overload capacity of 18,000,000 to 20,000,000 by dividing up the flow of gas through the inside boxes.

The circular steel outside catch boxes at this plant are 36 ft. in diameter, and 16 ft. high with an 8 in. brick encasing wall around each box. A box holds about 9,500 bushels of oxide in 3 layers each 4 ft. thick. At this plant, the gas enters at the

top, but this has been found to be not desirable, and in later installations, the gas is made to enter at the bottom.

MR. J. S. KENNEDY (New York): I was very much interested in Mr. Earnshaw's remarks on his installation, as it illustrates what may be done by working a set of purifiers at rates much beyond the capacity that is usually accepted as standard practice. The plant with which I am connected has an installation of boxes, the capacity of which would ordinarily be rated at between 4,000,000 and 5,000,000 a day, yet, by operating these boxes somewhat in the same way, as Mr. Earnshaw points out, we are able to purify during the winter 10,000,000 a day, and an average throughout the year of 6,000,000 cu. ft. a day. The boxes are all operated in sets of two each. Occasionally, we have had to run them single. Each box is equipped with a single layer of oxide. The oxide is never taken from the box from the time it is put in until it is finally discarded. The revivifications are done entirely *in situ*, by means of an exhauster, drawing a current of air down through the oxide. Of course, this means that the revivifications are very frequent. In the winter time, they run as high as five a day, with ten boxes in use, which may seem very abnormal, yet we get along very nicely. The gas which we manufacture is carbureted water gas. Of course, its sulphur content is not very high. While the boxes have single layers of oxide, underneath each layer there is a layer of shavings. We operate our boxes, so that when we finally discard the oxide, the sulphur content runs between 40 and 50 per cent. This is but another illustration of how increased purification capacity may be obtained by working the usual size plant at higher rates than has been customary up to the present.

MR. J. S. UNGER (Chicago): I do not intend to discuss Mr. Paige's paper, but it seems to me that in his coal gas works, with which I am somewhat familiar, they having an ammonia still, they might have utilized the ammonia in the gas liquor for purifying the gas, instead of putting in more purifiers. It is something which was brought before this Institute

last year. I understand Mr. Paige put in his new purifiers before that time, but, already there had been mention in other proceedings of the so-called O'Neill process of utilizing the ammonia in the gas liquor to take out most of the sulphureted hydrogen in the gas, and some very good results were published. In Schenectady, they have a new coal gas works and they did not enlarge their purifying capacity, but installed an ammonia still, in which the upper part will take care of about three times the liquor going to the lower part of the still. If the lower part of the still is dimensioned to drive out the ammonia from the liquor normally produced in the gas works, the upper part may be made to change two or three times this amount of liquor from a solution in which the ammonia is combined with the acid gases, into a solution of caustic ammonia, which is pumped into the gas scrubber, and there combined with the sulphureted hydrogen that otherwise, would have to be removed in the purifiers. The caustic liquor is cooled by the gas liquor going to the still and by cooling water, and afterwards put into a receiver, so the still does not have to run continuously, and may be operated in the daytime only. Before coming here, I spent two days at Schenectady, and the still ran perfectly and it seems to me that the O'Neill process is a success. I would like to ask Mr. Paige, whether he considered the O'Neill process at the time when a larger purifier capacity became necessary.

MR. R. C. MORRIS (Stapleton, Staten Island, N. Y.): I should like to ask Mr. Paige whether he experienced any difficulty in obtaining the labor to empty the boxes? Our laborers complain on account of getting sick in the head on a warm day in the summer, and also that it ruins their shoes and trousers on account of the water, and they do not care about going on for two days' labor. We have called in a gang of twenty to dump the boxes.

MR. R. B. HARPER (Chicago): There are a few questions I should like to ask Mr. Paige. One of them is as to the kind of gasket he used; another is, does he consider it absolutely

necessary to use the pitch coating? He said he used it in one box, and in the other he did not.

There are a few comments I might make. I notice on page 741, one of the answers in regard to insulation: "Box kept well painted." I have a case in mind, where the outside boxes were kept well painted, and it was found that although these were heated by means of steam injected at the inlet, and the issuing gas was at fully 80 degrees, in very cold weather, when the outside temperature was about 10 degrees below zero, a decided stain would show at the outlet of the fourth box, although in ordinary weather there would not be any stain at the outlet of the second. It shows that the men using these outside boxes should be very careful about them, especially in cold weather. The only explanation is that the outside of the box becomes greatly chilled, and some of the gas by-passes in a foul condition through chilled purifying material, next to the cold metal walls, thus giving a stain at the outlet of your fourth box. It has also been found where boxes are wooden lagged, the saving in steam will be large; it may be reduced to 25 per cent. of that necessary for an unprotected box, and in an installation of (say) twelve purifiers, where each purifier is of a diameter of about 40 ft., that means a considerable amount of money at the end of the year, and especially in climates that are rather severe.

MR. H. E. MANN (Montreal): (Written discussion communicated.) I agree with Mr. Paige that purifier boxes wherever possible should be erected in the open, and in this connection, a description of the purifiers recently installed at the Elm Station of the Montreal Light, Heat & Power Company might be of interest.

The installation consists of four cylindrical steel purifiers, 27 ft. in diameter by 12 ft. deep. These boxes will be used on water gas purification and will be worked in series of four, switching every three days, to place the foul box last and the clean box first in series. Each purifier will contain three layers of oxide 36 in. deep.

These purifiers are erected in the open and are protected by a 4-in. wall of old fire brick laid up in cement mortar. Between the fire brick and the steel shell of purifiers, a space of 1 in. was left, which was afterwards filled in with hot pitch. The pitch was applied to prevent corrosion of the steel plates. Each purifier is provided with a heating coil laid on the bottom of the box. The covers and 20 in. connections to purifiers will be protected with asbestos or magnesia covering.

This installation will be completed and ready for operation December 1st of this year. Careful consideration was given to the erection of these purifiers in the open, after taking into account the low temperature of the winter months. As the temperature during January and February will range from zero to 30 degrees below, we were at first inclined to house these purifiers in a heated building. We believe, however, that our method of protection will be sufficient to prevent any drop in the temperature of the gas and resultant loss in illuminants and revivification of the oxide.

MR. E. F. LLOYD (Detroit): (Written discussion communicated.) Mr. Paige does the industry a valuable service through bringing out the variety of practice existing in purifier installations. Moreover, he confirms the probability of its continuance. There is, in my opinion, no one best type for universal use under all circumstances and in all localities. Each situation has its peculiarities, yet all are amenable to certain general principles.

The design of purifiers for eliminating sulphur by the use of oxide, presents a purely mechanical problem. The various applications of the chemistry involved has no bearing on the form of the apparatus. The major divisions of the problem are to provide a series of connected gas tight containers of suitable area and depth, provided with means for sustaining, removing and replacing a filling material. As to what constitutes "suitable area and depth," no two authorities yet agree, doubtless due to variations in the qualities of the gas and oxides employed by the various investigators.

Minor divisions of the major divisions involve questions of the number and arrangement of units and connecting conduits, and the convenience, certainty and celerity of the means for cutting out and in of units; of corrosion, ventilation, insulation and drainage; of frequency of recharge, of the quantity of material to be handled each time, its protection from desiccation in transfer and the facilities for effecting the transfer.

I venture to say that ventilation cannot be overdone. Tank purifier operators have assured me that they never had a man killed in one of them, and with the same breath, continued that they are "hell to work in on a hot day," and they have had to pull men out, but, 'if you watch things, and get them out when you see them beginning to stagger, you'll be all right.' The man, too, presumably!

Let our first business, then, be to investigate what are the real essentials, divested of tradition, inclination or favor. Applying these factors each to our own case, we should have no difficulty in deciding upon the most economical installation, though it may be by no means either the highest or the lowest in first cost.

Such an investigation intelligently and carefully carried out, should easily, and with reasonable certainty, determine whether it is cheaper to build a building and maintain the required temperature in the purifiers by heating the building, or to occasionally heat the gas in the purifier. (Are not buildings and heating, traditions from the days of wet lutes?); whether it is cheaper to set the boxes and their connections in the ground and use the natural thermal conservation of the earth, or to place them on top and go to the expense and partial efficiency of an expensive covering; what difference in first cost is warranted to avoid corrosion or the expense of preventing it; what provisions are demanded for safety; what is the bearing of ample light and air on the proper placing of materials in the box; the effect of mechanical elevators in locally compacting the materials in the box; to what extent

the design should avoid special machinery for oxide handling; the standby costs of such machinery operating at the most but a few days a year; the deterioration of such infrequently used machinery, handling such a highly corrosive material as oxide; the difficulty of protecting it from corrosion; how much such infrequently used machinery actually reduces the labor cost; in large plants, the possibility of using locomotive cranes or telfer systems jointly with other purposes; the relative location of the revivifying floors and the means of transfer of materials; the methods of revivification; the ground area available relative to the capacity required; the probability of mechanical failure of the box and the ease and certainty of repair.

These are all problems for the mechanical engineer. They should be co-ordinated as to safety, life, maintenance, cost of operation, and certainty and continuity of performing their function. Wherever, so to speak, the curves of these conditions meet, we shall find the cheapest purifier plant, whether it costs least or most in the first instance.

Mr. Paige investigated steel-concrete for his particular situation, and became convinced. Others who use them endorse them equally. The elements of efficient economy seem to meet in them more than in other types. The early difficulties encountered with them have been overcome by development in their design and in the methods of constructing the concrete work. There appear to be few places where they are impossible, and many where they are best.

MR. F. E. DRAKE (Lynn, Mass.): I would like to ask Mr. Paige what drop in temperature he found through his boxes in winter months, and if he ever had any trouble in emptying the boxes during the winter months, and the length of time and the number of men required to empty the boxes.

MR. HARPER: Another question or two. One is, if he ever tried building paper as a gasket on boxes? I have seen cases where ordinary building paper, in strips about 3 or 4 in. wide, thoroughly wetted, and laid down in layers, about three or

four layers of paper, formed an excellent seal; whereas, the square asbestos gasket had failed. I am interested in knowing if any other members of the Institute have had any experience with ordinary building paper. It is a very cheap and a very efficient means of keeping the box tight.

MR. W. F. CROSTON (Newport News, Va.): I was connected with the Railway & Light Company of Rochester during the installation of the concrete boxes there. The boxes were made thicker than those mentioned by Mr. Paige. By careful work, using a good grade of cement, mixing it well and making each box a monolith, we had absolutely no trouble. There was but one slight leak on one of the four boxes. The boxes are placed about 3 ft. above the ground level, the dirt is banked up against the side of the box, and a sectional removable wooden cover was made for use in winter. With the use of this cover, absolutely no steam is necessary to keep the box warm. The cover stands about 2 ft. above the top of the box. It is really surprising how hot it was under that cover, even during the most severe winter weather. As far as getting labor to attend to this box, we never had any trouble. The boxes have given ample satisfaction, and I think the men connected with the Rochester Company are perfectly satisfied.

THE ACTING CHAIRMAN: Mr. Paige, will you close the discussion?

MR. PAIGE: In connection with the matter of purifier installations, I want to call attention to the fact that it was a most curious thing that all those who answered the questions, answered one question in a very peculiar manner. The question was: "If you were to build another installation, would you build it along the same lines as the one now installed?" Invariably, the answer was, "Yes," which perhaps was natural, but a little curious. Now, in connection with Mr. Unger's question on the matter of liquid purification, I think all of us have heard more or less about that from time to time. We knew something about the investigations carried on both at home and abroad. The Schenectady plan had been thought



about to some extent, but at the time the boxes were considered, it was too experimental a thing for us to consider it. In connection with Mr. Morris's question on the matter of labor in emptying the boxes, I might say that we have not had any particular trouble in emptying these boxes, which are 25 by 30 by 10 ft. deep, at any season of the year when we have been obliged to empty them, but we have had a great deal of trouble in getting men to empty boxes 25 ft. square and 5 ft. deep inside of a house. The inference is obvious.

As far as the ruining of men's clothing is concerned, that is a gas works proposition. The men may be fatalists to some extent, but our fellows are inclined to consider that if they do not ruin them in a purifying house, they will perhaps in the tar well. That is a question which every company has to face, regardless of what type of box might be used.

In connection with the matter of the kind of gasket used, you will find that (see page 737) many different kinds of gaskets are mentioned. It is a curious fact, in connection with that matter, that some companies have found that one type of gasket answers very satisfactorily, while in another case, the same type does not appear to work out well at all. I have in mind one plant where they are using rubber gaskets which have been in use for nine years, but even with that term of service, the plant operators do not feel that the rubber is the best material, and they intend replacing it soon with an asbestos woven gasket. In regard to the matter of pitch coating, I would like positively to say that I do not consider it at all necessary. Mr. Croston's remarks in connection with the Rochester installation concur entirely with my ideas. I believe that if the concrete is properly mixed, properly put in and thoroughly tamped, no coat of pitch will be found necessary, nor will it be necessary to chip off the inside surface of the box, as we had to. We learned a lot about concrete boxes when we built these. In connection with the insulation of the boxes, we feel that the thickness of the wall of the box is great enough to furnish us a considerable insulation. As the

paper points out, while the box is 10 ft. deep, the sides are only about 30 in. above the ground level, the remaining depth going below the ground. So the box is well insulated by the ground, and the piping connections also are filled around with dirt, so that the connections have reasonably good insulation.

As to the use of building paper as a gasket referred to by Mr. Harper, none of the 50 replies I received mentioned that particular type, so I am not prepared to discuss it. In connection with the trouble of getting men to empty these boxes in winter, Mr. Drake's question, I have not found that we have had any difficulty whatever in getting men to do this work. As I pointed out, the boxes are of such depth that it requires two-stage shoveling, that is to say, they shovel first on to a platform and then over the edge of the box; and while that might seem like rather an expensive method of unloading boxes, we balance the expense of that work against the available area, and the consideration of fixed charges for the securing of more ground area; and there are so many conditions that enter into the problem, that we did as well as we could towards establishing a mean which would minimize the greater difficulties. Practically we had no difficulty with the men. The question was raised with regard to the drop in temperature of the gas passing through. We have found that there is a slight difference in temperature in winter as compared with summer, but this is a difference which we would feel, to a large extent, in any event, because the main from the water gas exhauster to the purifiers stands for a considerable distance, and I do not have the figures exactly in mind, but I should say roughly that the temperature of the gas at the inlet of the purifiers varied approximately from 10 to 15 degrees, with the temperature at the outlet depending on the rate of flow. We found, however, that the drop through the purifiers increased quite a good deal at first, due undoubtedly to the radiation loss from the insufficient insulation of the covers of the boxes. To get rid of that difficulty, we housed over the 15 in. I-beams, which are on the covers for reinforcement,

with the result that the drop was not at all serious, and no effect on the candle-power could be noted. As far as finding the by-passing effect due to cool oxide is concerned, we never have observed any of that. I learned, through reading over the information sent in, that in the earlier types of outside boxes, this difficulty was quite pronounced, but some companies took care of that by the installation of steam coils, and some by the construction of an annular ring of brick, perhaps a single brick wall, or any other method calculated to keep the extreme cold from striking into the body of the oxide, and prevent by-passing or a retarded chemical reaction.

MR. EARNSHAW: I move that a vote of thanks be tendered to Mr. Paige for his very interesting paper.

The motion was seconded and carried.

THE ACTING CHAIRMAN: The next paper is "Care and Maintenance of Gas Holders," by Mr. J. H. Braine, of Brooklyn.

## THE CARE AND MAINTENANCE OF GAS HOLDERS.

### INTRODUCTORY.

The object of this paper is to treat from a practical standpoint the subject of the care and maintenance of gas holders. It does not purport to be solely an expression of the writer's personal views, or the experience of any one company. It is an endeavor to treat the subject comprehensively, embodying the experience of some of those best qualified to deal with the matter.

Undoubtedly those connected with the larger companies are familiar with the majority of the points covered, and the primary object of the paper is to point out to those not having the time and opportunity to study the subject closely, ways in which they may further safeguard the valuable property under their charge.

In looking over the ground to be covered, we find there are to be considered holders built during a period of years, from as early as 1850, or possibly earlier, down to the present day.

During the early '90's, we find specifications calling for "Alan Wood's best blue gas holder iron," while a few years later open hearth soft steel began to be specified. It is also probable that during this time many holders were built partly of iron and partly of steel. Specifications continued to call for mild steel for holder construction until quite recently, when a return to wrought iron for sections has been resorted to in the case of some holders of very recent construction.

We also find ourselves obliged to consider a great variety in design of guide framing, from the ancient cylindrical cast iron columns and cast iron girders, and wrought iron columns and girders of the same design, to the "standard" type of guide framing first introduced into this country by the late Mr. Fred Mayer, of The Bartlett Hayward Company, and in turn the many improvements in design of this type of framing until we reach the last word in holder design typified in some recent holder construction which will be touched upon later.

In caring for holders built of good old fashioned iron, we have a comparatively simple problem, as it is certainly a fact that this old iron is very much less vulnerable to corrosion than modern steel, whatever the relative powers of resistance to rust of modern iron and steel may be.

In caring for the more modern steel holders, built within the last 20 years, we have a much more serious problem, and it is mainly to sound a note of warning regarding these that the first part of this paper is written, in the hope that some of us may, by a little timely attention now, be saved the otherwise inevitable heavy expenditures for repairs in the near future.

The first chapter of this discussion is devoted to the subject of corrosion, the arch enemy of exposed metal structures in general, and steel gas holders in particular. The whole subject is a difficult matter to deal with, as new data is constantly appearing in the technical press, and new theories are arising with their advocates and opponents, and the consequent more or less heated controversies.

## CORROSION.

Owing to their light construction, as compared to bridges, elevated railway structures, viaducts, etc., gas holders, and particularly gas holder frames, are peculiarly susceptible to the destructive action of rust or corrosion. Many theories as to the cause of rust or corrosion have been set forth, Friend\* mentioning as many as five, namely:

1. Simple Oxide Theory.
2. Acid Theory.
3. Electrolytic Theory.
4. Hydrogen Peroxide Theory.
5. Biological Theory.

while Cushman & Gardner\*\* confine themselves to three, namely:

1. Carbonic Acid Theory.
2. Hydrogen Peroxide Theory.
3. Electrolytic Theory.

It is, however, becoming very generally conceded that the electrolytic theory is the most tenable, and much of the experimenting and laboratory work with protective coatings, improvements in the manufacture of metals, etc., have been carried on with this theory in mind. It is, of course, very necessary for us to know the primary cause of such an agent of destruction as corrosion, and it is sincerely to be hoped that our friends, engaged in the manufacture of steel or iron, and their preservative coatings, will soon have definite data with which to work.

In this connection, the following extract from a paper read by Dr. G. W. Thompson, before the American Institute of Chemical Engineers, June 22nd, 1910, may be of interest:

"By corrosion of iron and steel, we refer to the oxidation which takes place at ordinary temperature, with the formation of rust. Rust approximates the following formula:



\* J. Newton Friend, "The Corrosion of Iron and Steel."

\*\* Cushman & Gardner's "Corrosion and Preservation of Iron and Steel."

although all rust does not exactly conform to this formula.

"A sample of rust, obtained by exposing a thoroughly cleaned piece of steel, that is a steel which has been pickled to remove scale, etc., analyzed as follows:

	Per cent.
Hygroscopic moisture .....	8.83
Combined water (including CO <sub>2</sub> 0.17 per cent.) . . .	21.45
Ferric oxide (equivalent to iron 48.28 per cent.) ..	68.97
Silica .....	0.26
	<hr/> 99.51

"A very important consideration in connection with the formation of rust is:

"The specific gravity of iron is about 7.80, and the specific gravity of rust is about 3.70. If the iron and the rust are strictly pure and of theoretical composition the iron shows an increase in volume in conversion to rust equal to 336 per cent.; that is, 100 parts of iron become 436 parts of rust by volume. . . .

"The prime material factors in corrosion are air and moisture, and the action of air and moisture is accelerated or retarded by other factors.

"The tendency of iron to corrode has been considered to vary with the composition of the metal, but, apparently facts do not warrant this conclusion to an extent that would justify general dependence on a purer and more expensive metal as against a more impure and cheaper metal. Practical experience may justify such a dependence in isolated cases, but not as a general rule.

"Nevertheless corrosion, which usually takes place in the form of pitting, is unquestionably due to the greater tendency of the pitting parts to corrode than the adjacent parts. Such corrosion is said to be due to a higher electrolytic solution pressure, as compared with the adjacent parts, and the corroding area is said to be electro-positive to the surrounding area. This, of course, refers to primary corrosion, to which most of our remarks will be directed.

"The corroding operation is supposed to be, first, a solution of the iron in the water and, second, the oxidation of the dissolved iron by the air, with the formation of ferric hydrate or rust. This solution would not take place without the water being present, nor would the oxidation take place in the absence of air. The solution of the iron is accelerated by the presence of carbonic or other acids and neutral salts, also by the presence of substances which are electro-negative to iron. The corrosion is furthermore accelerated by the presence of substances or conditions which increase the amount of moisture on the surface, as by hygroscopic substances, such as rust itself or a moist atmosphere."

The following represents the views on this subject of an engineer of wide experience with structural metals in general, and gas holders in particular. All parts of the text of this paper, which may hereafter appear as quotations and for which no authority is given, are from the same source:

#### THE DETERIORATION OF GAS HOLDERS.

"The importance of arresting the rapid decay of iron used in structures of all kinds, and especially gas holders, is a problem of much interest.

"Many theories have been advanced to account for corrosion, and while some of them have been discarded, others surely bear investigation, and before proceeding with a statement of the effect upon gas holder material, it may be well to dwell at short length upon the cause.

"The usually accepted theory of a few years ago, was that rusting or oxidation was entirely due to a chemical change, in which water, carbonic acid, and oxygen were the prime movers in that the process of decay was induced by the carbonic acid, after which the water and oxygen became the active agents in its further development.

"This was an erroneous view, as later investigation proved that although the presence of carbonic acid was found favorable to this process of decay, it was not es-

sential, and consequently other reasons for this rapid deterioration of metals were sought.

"The general accepted theory adhered to by present day investigators is that corrosion of iron is due to an electrochemical phenomenon, or to an electrolytic influence, not necessarily induced by some stray current from the electric plant, but due to the construction itself, and unfortunately, in many instances, this construction cannot be altered, as witness the cups of a gas holder.

"Iron, and under this term, I mean the iron and steel of the present day, is a metal which finds no difficulty in combining with or dissolving a number of the other elements, and it is a well known fact that minute quantities of impurities in the mass will be sufficient to greatly alter the physical characteristics, thus causing the manufacturer to carefully examine, down to the minutest degree, the principal impurities which are usually found in combination with iron; these are manganese, phosphorous, sulphur and carbon.

"One of the principal difficulties encountered in the manufacture of steel is due to the fact that these impurities are not homogeneously distributed, and that when the mass cools, segregation takes place, and the steel no longer maintains a unit character throughout its mass, one portion containing more or less impurities than another, it not being a homogeneous pure metal.

"Owing to the general pollution of the atmosphere and of the water which comes in contact with the metal, due to the waste gases arising from numerous chimneys, often also containing finely divided ash, the problem of dealing with corrosion has greatly increased in magnitude. The sulphurous acid carried into the atmosphere, and any possible stray electric current is probably the chief stimulant of corrosion.

"Electrolysis will take place when an electric current passes through any solution which may act as a conductor,



and this may be produced without the outside aid of any stray electric current, as is witnessed by placing two different metals in a solution, the metals being connected by a wire at the top, and noting the electric current which is immediately caused to flow through the circuit thus formed; and the iron or steel of to-day, in its segregated structure, presents sufficient dissimilarity to produce the above mentioned condition.

"In the first stages of corrosion, ferric-hydroxide is formed on the surface of the metal by the above described electrolytic action, this compound being insoluble and gradually falling off as a red precipitate. This precipitation removes a quantity of the metal.

"It is not necessary that the iron be dipped into water, but the condensation of a thin film of water on its surface will suffice to produce this condition, in that it tends to dissolve the metal. When an atom of iron passes into the water, it is charged with positive electricity, while the mass of iron from which it has been separated is charged with a negative current, and so continues until the electrolytic tension becomes of such magnitude that no more atoms can be separated. If the water should contain ions of some other metal which is subject to a lesser solution pressure than the iron, the above action will be reversed, thus again placing the iron under the original condition and permitting of further interchange of polarity with the consequent deposition of additional atoms of iron in the water. The impurities in the iron are in themselves capable of setting up this second action without the addition of any extraneous metal of a lesser solution pressure.

"Iron will rust in the presence of pure water and oxygen, without the addition of any extraneous acid, and as pure water contains free hydrogen ions, the iron probably dissolves through interchange with the hydrogen, and to this extent becomes an acid; this would then point to the

fact that the rusting of iron is not primarily due to the oxygen, but to the hydrogen ions.

"The theory of corrosion can then be summed up in the following statement:

"Whenever rust is formed it is necessary that the iron go into solution, and it is also necessary that hydrogen be given off in the presence of oxygen (or in some cases in the presence of other oxidizing agents). This statement is based upon the electrolytic action described above, as this theory demands that whenever an iron ion appears, an ion of hydrogen must disappear, this interchange of ions forming a gaseous hydrogen. If the solution should contain any acid which causes greater concentration of hydrogen ions, the corrosion will be increased.

"Therefore, it is to be taken for granted, and all late experiments seem to have proven the case, that iron possesses a solution pressure. (Solution pressure is the motive power which tends to cause the atoms of a metal to distribute themselves among the atoms of a solution.) This pressure is not always the same for the same material, as the impurities in both the iron and in the water change it, and the segregation of impurities throws the surface out of equilibrium, thus producing a varying solution pressure in the mass.

"Where maximum solution pressure occurs, the point will be positively charged, and where minimum solution pressure is found, they will be negatively charged, this condition only requiring that the two points be brought into contact by means of a conductor, a film of water being sufficient to bring about this result, and rapid corrosion is the consequence. The iron atoms are now precipitated into the water as ferrous hydroxide, which in turn are oxidized by the atmospheric oxygen (dissolved in water) into an insoluble ferric state, causing the deposition of rust.

"From the foregoing, it is seen that before rust can be

formed the iron must pass into solution, this producing an electric current which is caused to flow from the iron at one point to the iron at another point, and if the sulphur gases from factory chimneys should permeate the atmosphere, or if some other like circumstance should prevail, this flow of current will be increased and the solution of the iron will be accelerated. The surface of the iron possesses different degrees of potentiality and this difference produces the necessary degrees of solution to maintain the current, the difference of potentials being due to the uneven distribution of the impurities contained in the steel.

"Manganese, not exceeding one per cent., present in the steel is conducive to corrosion, because its presence reduces the iron's conductivity, and if sulphur is present, the condition is aggravated, as manganese sulphide is formed, which in turn is oxidized by the oxygen in the water and sulphuric acid, and manganese oxide are the resultants, permitting the sulphuric acid to act locally wherever the manganese oxide is found.

"Under these conditions, it is self-evident that iron or steel must necessarily give up some of its valuable qualities, or in other words it is weakened by the removal of some of its parts. The process of oxidation does not as a rule take place at ordinary temperatures unless moisture is present, and in order to prevent this condition moisture must be excluded. To the ordinary action of air and water, we must include such secondary causes as accelerate corrosion as the absorption of moisture, presence of acids, rough surfaces produced by scale, etc., the uneven distribution of foreign matter, and electric currents induced by outside conditions.

"If the electrolytic action described above could be obviated, corrosion would not take place, but the manufacture of steel or iron has as yet not reached that stage of per-

fection which would preclude those inherent qualities which in themselves produce this condition. . . ."

There is another point of view which clearly indicates the necessity of preservation of steel and iron structures against corrosion, and that is, the ever present problem of conservation. This is startlingly illustrated when we have brought to our attention the fact that the production of pig iron in the United States alone for the year 1913 was 31,000,000 tons, and a number of tons of coal, or equivalent, was used in making one ton of finished steel from ore.

#### MATERIAL, STEEL VERSUS IRON.

There is no doubt that the iron used by the ancients was much less subject to decay than the present day material. Many examples of such iron, which have been brought to our attention by travelers and archaeologists, and even some of the specimens which are still performing their functions to-day, conclusively prove that the iron of our forefathers was a very much more durable metal than that in use to-day.

A quotation from Cushman & Gardner's "The Corrosion and Preservation of Iron and Steel," will be appropriate here:

"Sang says as follows: 'Carelessness of manufacture, which tends to heterogeneousness, is an invitation to corrosion and in itself goes far to explain why modern steel, which is tortured into shape at such a high speed that the molecules are not permitted to readjust themselves, is said to be more corrodible than the metals produced a generation ago; in those days iron and steel were produced in small quantities, without the addition of other metals, and were rolled slowly and were allowed to cool naturally. The internal strains due to mechanical treatment are not to be confounded with the unevenness in the distribution of the impurities due to segregation in cooling; these mechanically induced strains are really equivalent to straining the metal beyond the elastic limit which, as will be seen later, makes it more corrodible. Moreover, the tonnage-craze, from which the quality of product in so

many industries is to-day suffering is causing to be placed on the market a great mass of material, only a small proportion of which is properly inspected, which is not in proper condition to do its work:—rails and axles which fail in service and steel skeletons for high buildings which may carry in them the germs of destruction and death.' . . .

"The authors (Cushman & Gardner) are satisfied to reiterate their previously published opinion that there is great variation in each type of metal in rust resistance and that in this respect there are good and bad irons, just as there are good and bad steels. If this is true, and a mass of evidence seems to support the statement, it is useless for manufacturers of the different types, through their agents, to engage in endless polemical debates over the comparative excellence of their respective products. The proper control of unavoidable impurities, their homogeneous distribution and a careful heat treatment, particularly as far as the annealing processes are concerned, will improve the rust-resistant quality of metal, whether it is called iron or steel, and regardless of the method by which it is made. . . .

"No thoughtful person supposes that it would be practically possible to return to the earlier laborious methods of iron manufacture, in order to produce metal highly resistant to corrosion. The modern problem must be solved by modern economic methods, and there is no reason to suppose that great improvements will not be made in the quality of both iron and steel, as soon as the principles governing the rate and kind of corrosion which takes place on different types and kinds of iron are thoroughly established."

It is interesting to note, in connection with the above, that some holder designers are now recommending a steel containing small percentages (about 0.2 per cent.) of copper, and also that a holder has been recently completed, the sections of

which are constructed of iron analyzing 99.8 per cent. pure iron, and the guide frame and tank of open hearth steel. During the construction of this holder, it was necessary to replace a number of sheets, which were rejected by the inspector. It was found impossible to secure wrought iron sheets of the dimensions required on short notice, and steel sheets were substituted. The location of these sheets has been marked and their resistance to corrosion, as compared with the neighboring wrought iron sheets, will be an interesting subject of observation.

Knowledge on this subject, however, is incomplete, and much research work has yet to be done. We may, however, leave the decision in these matters to those having the immediate responsibility for the design of, and material to be used in, new holder construction, as we are more primarily concerned with the care of existing structures, the nature of the material of which we cannot change.

#### GENERAL CONDITIONS FOUND UPON INSPECTION.

The general belief, as to the more or less indestructible nature of metal structures, will be somewhat upset by a close examination of the light frame work and sections of modern steel gas holders. A casual inspection shows them to be apparently in good condition, but a careful scrutiny will serve to show their extreme susceptibility to corrosion. It will not be exaggeration to say that neglect to properly safeguard these structures against corrosion will result in the distortion of members, and the possible impairment of the stability of the structure.

The foregoing remarks apply more particularly to holders located in damp climates and near the sea coast; those at high altitudes and in dry air being in less danger. After once forming, however, rust continues at a rapid rate, even in dry atmospheres, owing to the porosity of the rust, and its consequent retention of water.

The rate of corrosion will vary greatly in different structures, and even in different parts of the same structure. This

is undoubtedly due to carelessness in the manufacture of steel, the different parts of the same structure having metal of an entirely different composition.

### *Faults in Design.*

Faults in the design of some of the comparatively modern holders, as far as the possibility of protecting them from corrosion is concerned, are astonishing and lead one to the belief that the perishable nature of modern steel was not given due consideration by the designers of such holders.

" . . . Within the last few years, we had occasion to inspect the condition of 63 gas holders, some of which were erected as far back as 1853, and I shall endeavor to give a short, concise description of the condition of these holders at the time of inspection. . . .

### *Holder Proper.*

"In some of the very old constructions, it was found that the holder shells and crown were almost completely gone, and therefore the original cause could not very well be established, although from later investigations, it appeared that decay originally began at those parts which were periodically in contact with water, and proper precautions not having been taken to remove this original evil, the decay crept from sheet to sheet until the entire structure was affected.

"When it is remembered that in the case of a gas holder, conditions exist which do not pertain to any other structure, such as a longer or shorter period of suspension in the air, or in the chemically foul water of cups and tanks, and the emergence of the holder covered with water into the hot, and at other periods into the cold atmosphere, it is remarkable that the material did not decay much earlier, and this can probably only be attributed to the metal itself, which at the time of building was made by quite a different process from that which prevails at present.

"Later constructions showed deterioration at the cup and grip sheets, and, if not properly cared for, at the sheets next to cup and grip, at the vertical legs where they were attached to the shells; under and around the carriages and rollers, and between the shells and outer friction plates, if such were used.

"The holder plates decayed through the usual action of the water inducing electrolytic action, but the material under the carriages could have been protected by proper care, while the friction plate construction was bad in itself, as, if moisture once entered between the plate and the shell the damage was done, and it became only a matter of time when the material in immediate contact under the plate was compelled to decay, as there was no means of arresting this action after it had once been started. The connection of vertical leg to shell was probably affected through the shell material itself, as the decay here quickly induced the same condition in the surrounding material.

"Other causes of decay were very thin metal, which prevented caulking of sheet to sheet, and produced the necessity of placing some sort of joint material between the plates, instead of making all joints metal to metal. This joint material, by the action of time, gradually disappeared, and thus left openings for the admission of moisture until the entire material became affected, as the point of attack was so located that preventive measures were of no avail; the removal of the joint material also produced pockets which admitted foreign material and accentuated the possibilities of decay.

#### *Guide Frame.*

"The guide frames of the very old holders were usually constructed with cast iron columns, and steel or cast iron girders, the use of wind ties not having become common owing to the greatly reduced capacity, and consequently



size, of these holders when compared to modern structures.

"It was invariably found that the bolts in the joints of the columns rusted out, and as these columns were open to the weather at the top, rust usually formed on the inside with consequent deterioration. The girders were usually bolted to the tops of the columns and here also, due to the accumulation of dirt, moisture was permitted to enter with the usual result.

"In the constructions prevalent up to a few years ago, the guide frames were built of a multiplicity of parts, and the girders as well as the standards were usually supplied with cover plates; these latter were a source of great annoyance, as moisture usually penetrated between the members and corrosion immediately followed, the usual method of construction precluding the possibility of proper cleaning and repainting these joints. Some instances have come under my observation which showed an accumulation of rust from 1 in. to 1½ in. thick, causing the cover plate to belly out between the rivets, and at times to such an extent as to shear off the rivet heads.

"The method of connecting the girders and the diagonals to the standards were also very often of such construction as to form pockets for the deposit of dirt with the consequent evil effect, this condition also being of such a character that rivets were forced out of the connections and the structure thereby greatly weakened.

"The shape of the material used was also at times not a proper selection, and especially was this the case with the usual great amount of lattice work employed in former constructions, each joint in such a lattice structure forming an exceptionally advantageous point of attack.

"It was also noted that in many instances rivets did not fill the holes, and consequently after the frame had been subjected to the usual racking effect of wind storms,

these rivets would work loose, opening up points of attack, which could not be detected by means of the usual casual inspection. This condition was accentuated wherever bolts were used in connecting the various members of the frame.

### *Steel Tanks.*

"Of the entire structure the tanks were least affected by corrosion, probably due to the fact that there were less parts and less joints open to attack.

"The top shell sheet at the water line, with the tank rails at the same level, are the points where corrosion is usually found first; the coping is also subject to attack, if water is permitted to accumulate and remain on the plates. Loose rivets, producing weeps, are also points of special attack, and unless immediately caulked, may lead to serious consequences in time.

"The method of connecting the standard supports to the tank shell in the older construction also produced considerable corrosion, as this joint was generally of such a nature that dirt would accumulate and absorb moisture.

"The bottom curb and outer edge of the tank bottom, where it rests upon the foundation also are points of attack, if not properly cleaned and protected. . . ."

A number of instances have also been taken by the writer as further illustrating where corrosion may be looked for, and notes included covering remedies applied in the various instances.

In order that the references may be clear, the nomenclature of the various parts of the frame work of a modern holder are given in Fig. 1.

### *Standard Supports.*

In numerous instances, the standard support will be found secured to the tank plates by means of two Z bars connected to the front chord of the standard support, thus leaving an inaccessible pocket or space, with a depth corresponding to

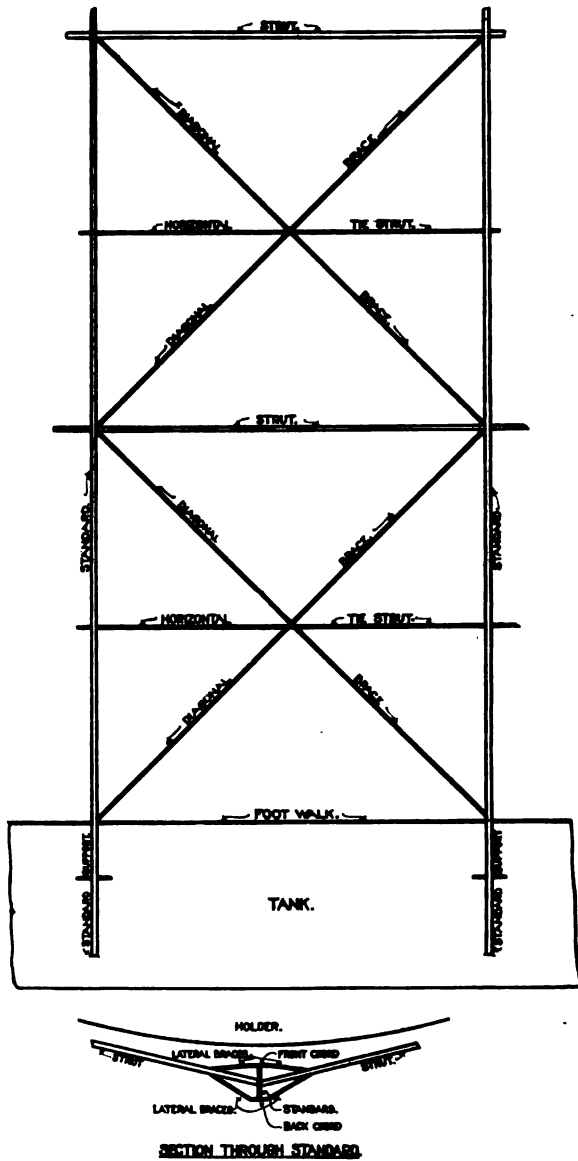


Fig. 1.—Gas holder frame work. Page 777.

the depth of the Z bar, and width corresponding to the width of front chord of standard support. This condition is illustrated in Fig. 2, showing a 5,000,000 cu. ft. holder built in 1904.

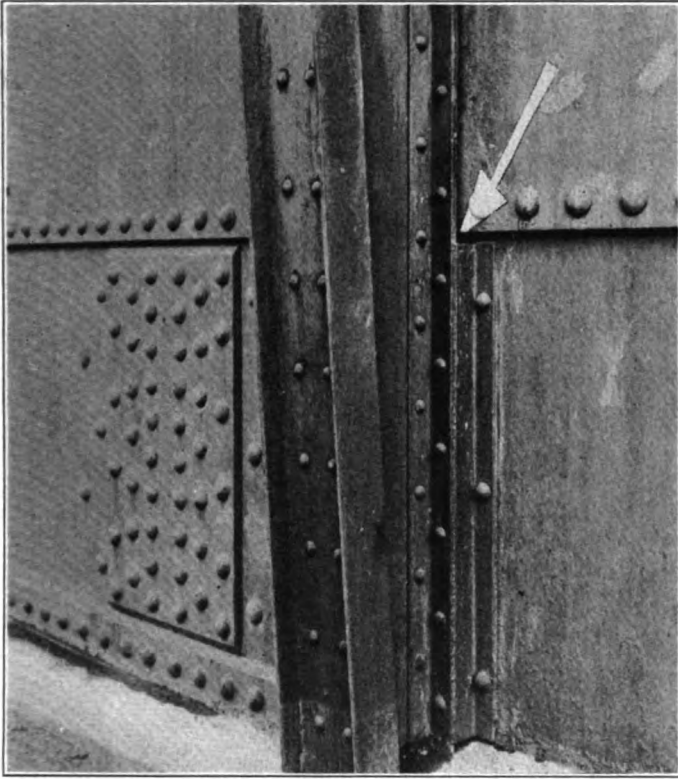


Fig. 2.—“Z” bar attachment of standard support. Page 779.

In many instances, the bottom set of these Z bar connections will be found embedded in the concrete wall, the space being filled with sand, cement, roof cement, paint skins, and any one of a dozen different compounds, all of which shrink away from the metal, allowing air and moisture to enter, and corrosion to go on at a rapid rate.

These pockets should be cleaned out at any cost, and the metal surfaces thoroughly cleaned and painted. It will probably be necessary to cut hand holes in the web of Z bars in many instances. It has been found possible, however, in

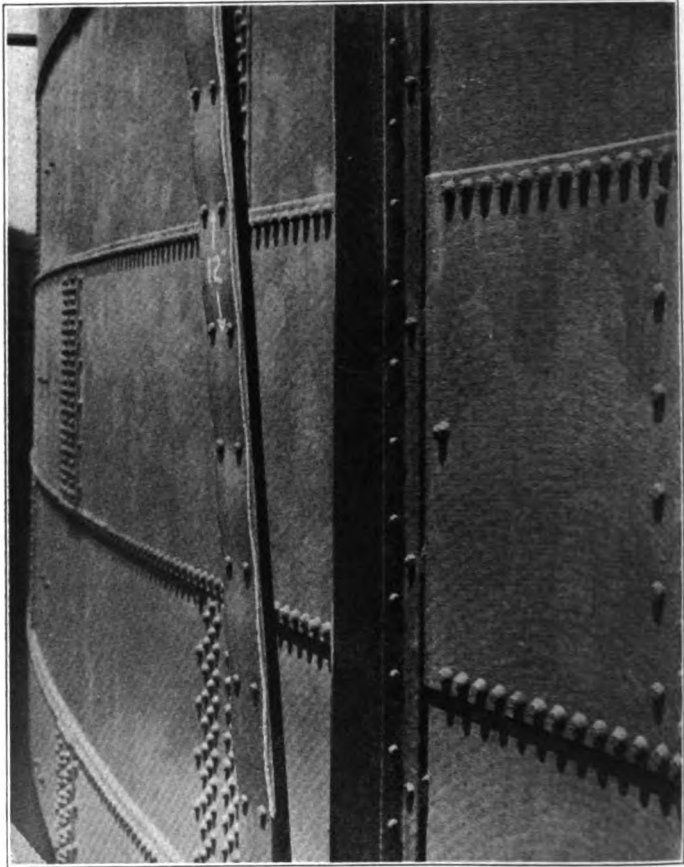


Fig. 3.—Buckled cover plate. Page 781.

some cases, to clean out the space in question, where only the openings have been sealed with cement, and to scrape the inner surfaces by means of a piece of wire cable, with the

strands turned up to form a rough brush, after which paint can be applied by drawing a swab back and forth by means of lines operated from above and below the pocket. The standard supports have also been found corroded where they enter the concrete or brick guard walls. This question is taken up later under the heading of "Tanks."

In the older type of steel tank holders, a cover plate was frequently used on the back chord of standard. In these instances, as in many others, no regard appears to have been paid to the pitch of rivets necessary to properly secure the plate against buckling.

The condition, as shown in Fig. 3, taken from a 1,500,000 cu. ft. holder built in 1892, has, of course, been increased by corrosion, but undoubtedly has existed to some extent since the assembling of the guide frame. There does not appear to be any remedy for this condition, other than the renewing of the plate and the insertion of additional rivets.

#### *Tank.*

It has become a general practice to surround the portion of steel holder tanks below grade with concrete or brick walls.

" . . . The action of the metal of the tank behind concrete protective walls, as well as the action of the iron imbedded in the concrete, cannot at present be spoken of authoritatively as the use of these walls is only of recent years, and no experience has as yet been gained in this direction.

"The concrete should be placed directly against the tank shell without leaving any voids, and if these should be found they should be filled with asphaltum or some other such compound. The caustic lime in the cement should be a preventative of corrosion, for as stated above, iron in an alkaline solution will not corrode, but this will only remain so as long as the cement retains its caustic properties; as soon as the cement absorbs carbonic acid from the air, the caustic lime is converted into insoluble carbonate of lime which induces corrosion. Therefore,

it is necessary that the concrete be brought into perfect contact with the metal, and the concrete be covered with a protective coating, as the absorption of the carbonic acid may cause the concrete to recede from the metal and



Fig. 4.—Corrosion of tank plate. Page 784.

thus permit moisture to enter, with the consequent evil effect." . . .

It has been found that these walls do not remain in intimate contact with the steel tank walls, a considerable space appearing between the concrete or brick wall and the steel wall, after a short space of time. An examination was made of a

number of these steel tanks, where they had been covered by a wall, the result of which is shown in the following illustrations:

The dimensions given in each figure showing the depth to

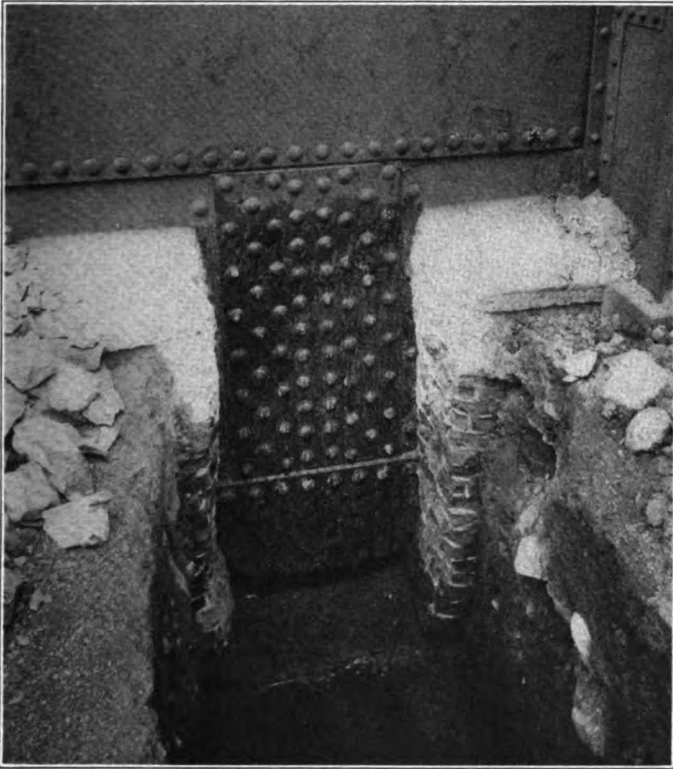


Fig. 5.—Corrosion of tank plate. Page 784.

which corrosion had progressed, this corrosion being only of a primary nature, no signs of deep pitting having as yet appeared.

The plates below the line show superficial corrosion only, and those without dimensions, show superficial corrosion only over the entire surface exposed.



Fig. 4 is taken from a 5,000,000 cu. ft. holder built in 1904.

Fig. 5 is taken from a 5,000,000 cu. ft. holder built in 1903.



Fig. 6.—Corrosion of tank plate. Page 784.

Fig. 6 is taken from a 3,000,000 cu. ft. holder built in 1903.

Fig. 7 is taken from a 500,000 cu. ft. holder, the date of erection of which is not in the writer's possession.

Fig. 8 is taken from a 500,000 cu. ft. holder built in 1898.

It was thought in the case of this holder that the apron projecting over the top of the guard wall, and from which

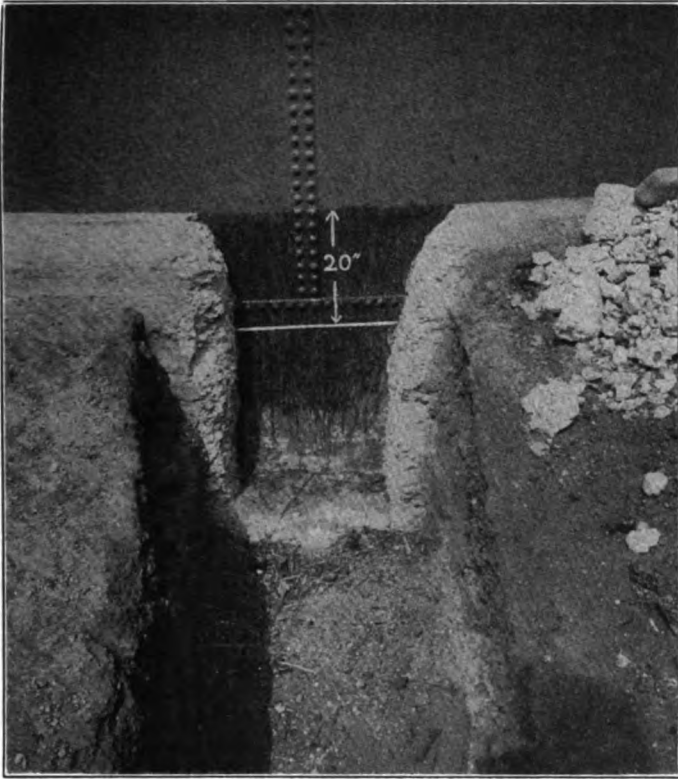


Fig. 7.—Corrosion of tank plate. Page 784.

the brickwork had drawn away, would have a tendency to collect moisture and promote rapid corrosion, such, however, was not found to be the case.

Some holder designers preferred the guard walls to stand away from the steel tanks, thus allowing a space for inspection and painting of steel tank. In the annular space thus

formed, between tank and wall, water will accumulate during a storm, and will in time disappear through absorption and evaporation. This constant change of conditions will be found a very severe test upon any paint used on the bottom courses of the tank and the bottom curb angle. These will

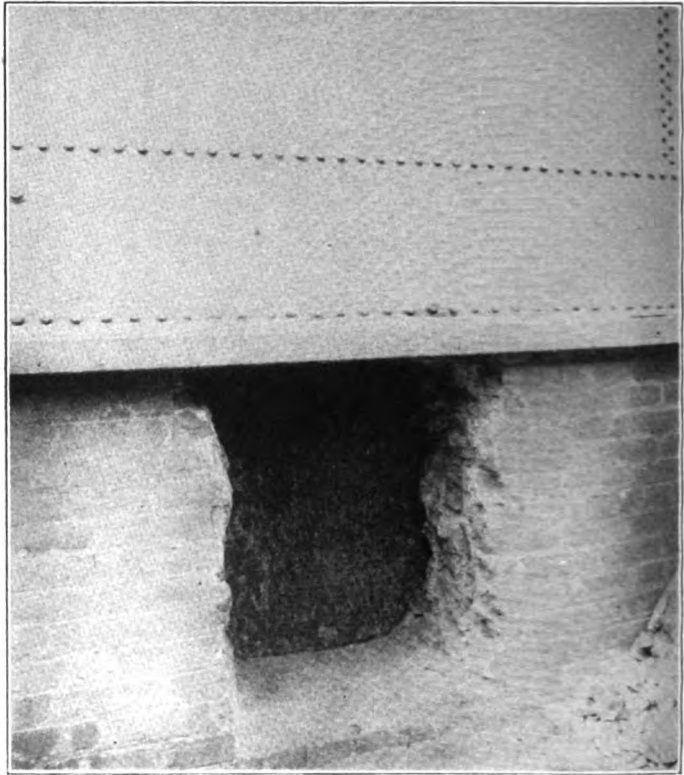


Fig. 8.—Corrosion of tank plate. Page 785.

need frequent and careful attention to prevent them from seriously corroding.

Notwithstanding the comparatively small amount of corrosion, disclosed by examinations, of tanks below the guard walls, it was considered advisable to check this, if possible,

as in the course of time serious damage to the tank walls might occur, and the following method was resorted to:

So called "elastic cement" was used for this purpose. This cement is furnished by a well known manufacturer and may be readily secured. About three barrels were found sufficient for a 5,000,000 cu. ft. holder.

The cement is heated until it is about the consistency of molasses. It must not be allowed to boil, as this destroys its elastic qualities.

A V shaped space should be cut in the top of the masonry wall, next the steel tank, and the cement poured therein until it takes its final level. Several applications can be made, the cement bonding after a few days. The wall must be approximately level at the top, otherwise the cement will, in the course of time, find its way to the lower part of the wall and flow out, leaving voids at the high points. The steel tank walls and the masonry walls must be perfectly dry when the cement is applied, otherwise the bond between the masonry and the steel tank will be defective, allowing moisture to find its way in.

Experiments have been made with pitch or asphaltum spread over the top of elastic cement, in an endeavor to keep it from creeping. In the writer's experience, this has not been necessary and no protection over the elastic cement is used.

In the case of brick walls around holder tanks, two methods have been resorted to:

The top of the annular space is filled with elastic cement in the same manner as that resorted to in the case of concrete walls. In addition to this, holes are drilled at points considerably below grade, and cement grout used under pressure until it shows at the top of the walls. This is done as there is no assurance that the brick walls are air tight.

The elastic cement referred to in the above description is of such a nature that it remains permanently plastic.

The chemist's report on this compound is as follows:

## ANALYSIS OF ELASTIC CEMENT.

	Per cent.
Insoluble matter, principally lead sulphate, $\text{PbSO}_4$ ,...	25.67
Iron oxide, $\text{Fe}_2\text{O}_3$ .....	36.88
Calcium sulphate, $\text{CaSO}_4$ .....	19.42
Calcium carbonate, $\text{CaCO}_3$ .....	0.59
Magnesium carbonate, $\text{MgCO}_3$ .....	14.07
Undetermined .....	3.37
	<hr/>
	100.00
Solid matter (as above analysis).....	88.04
Oil vehicle (nature not determined).....	11.96

*Test of this Compound.*—A piece of iron pipe was polished and coated with cement. It was then treated with hydrochloric acid and the compound was then scraped off. The results showed that the coating protected the iron from the acid. This pipe is sent herewith marked with blue line. The part "A" has been protected by the coating and retains the luster; the part "B" was unprotected and has been affected by the acid. This test would indicate that coating forms an efficient protection against corrosion.

Frequent examinations of this compound, after application, show it to be very effectively sealing the annular spaces referred to above.

*Guide Frames.*

Many guide frames of comparatively recent construction have horizontal tie struts formed of angles connected by means of lattice bars. In many instances, the ends of lattice bars extended several inches beyond the rivet, under which projecting end corrosion formed, spreading along lattice bar where it was in contact with angle, distorting the bars materially and making the cutting out of rivets, cleaning of members, and their straightening out and replacing necessary.

In replacing the lattice bars, the projecting ends should be cut off, leaving just sufficient metal to give the rivet its proper strength. This condition is shown in Fig. 9, which was taken from a 5,000,000 cu. ft. holder built in 1904.

Another frequent cause of corrosion is found in the pockets formed by diagonal members of the open type of standard. In many instances, these diagonal members are formed of channels and on every alternate tier of standards these channels are framed into the back chords of standards with flanges

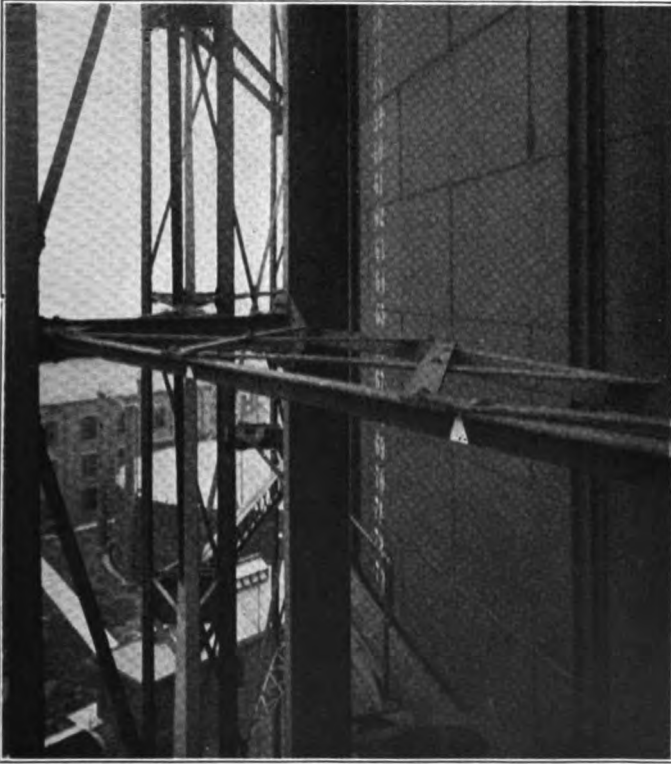


Fig. 9.—Corrosion of projecting ends of lattice bars. Page 788.

towards the web of I beam forming the chord. As the standard narrows toward the top, these diagonal members form an acute angle with the back chord, making a deep, narrow pocket which it is impossible to properly clean. In some instances, this pocket was filled with cast iron wedge shaped

blocks, which retarded, but did not entirely prevent the formation of rust. In cases where these blocks were not installed, corrosion attacked the channel from the inside, hammer tests developing the thinness of the metal, the outside being still coated with paint, and the member apparently intact.

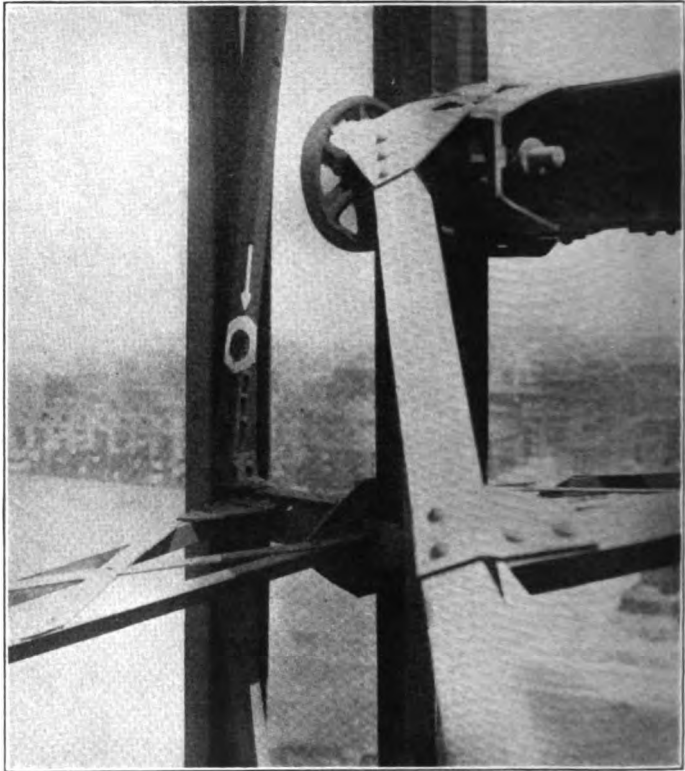


Fig. 10.—Pocket formed by diagonal member. Page 790.

This condition is shown in Fig. 10, which is taken from a 5,000,000 cu. ft. holder, built in 1903. The replacing of member seems to be the only remedy.

Foot walk plates have also been found to have insufficient number of rivets, where the plate is fastened to the horizontal

member supporting it, corrosion forming at these points and forcing the plate up. Additional rivets between existing rivets in these walk plates have been found necessary. Small pockets in the frame work, between the butting ends of members have been found badly corroded. All edges of plates, members, etc., particularly where such edges are in a vertical position, have been found to corrode and spread, and caulking of these vertical joints has been deemed advisable.

The ends of diagonal braces, beyond the last rivets have been found corroded underneath. This corrosion forces the member up, and endangers the stability of this particular member. This can be arrested by the use of a thin scraper or hack saw blade.

Corrosion will also be found at points where diagonal braces intersect, particularly where plates are inserted between them. In cases where the diagonal members are formed of round rods, it was customary in the past to provide ornamental junction plates of cast iron. In many instances, upon the removal of these ornaments, the rods were found very badly wasted. In fact, it has been found advisable to remove all ornamental parts of frame work on holders, which are not necessary to their stability. In some instances, flat or angle shaped diagonal braces, when such braces have been found badly corroded, have been replaced with round rods and turn-buckles.

Brackets holding guide rails on standards frequently have fillers placed behind them, and in many instances have been found forced out of alignment by corrosion.

#### *Carriages.*

In many of the earlier holders, no provision was made for draining the carriage bed plates. This was especially so in the case of top carriages. Fig. 11, taken from a 1,000,000 cu. ft. holder, built in 1890, shows a carriage which constitutes a completely enclosed box section. Examination showed the crown sheets to be badly wasted and resulted in the cutting of hand holes, and drilling of drain holes in the carriages.



In a number of instances, on holders built even within the last few years, counter weights were provided which were placed inside the goosenecks supporting top carriages. Their presence was not reported in a number of instances by painters and inspectors, and when finally removed, the crown sheets

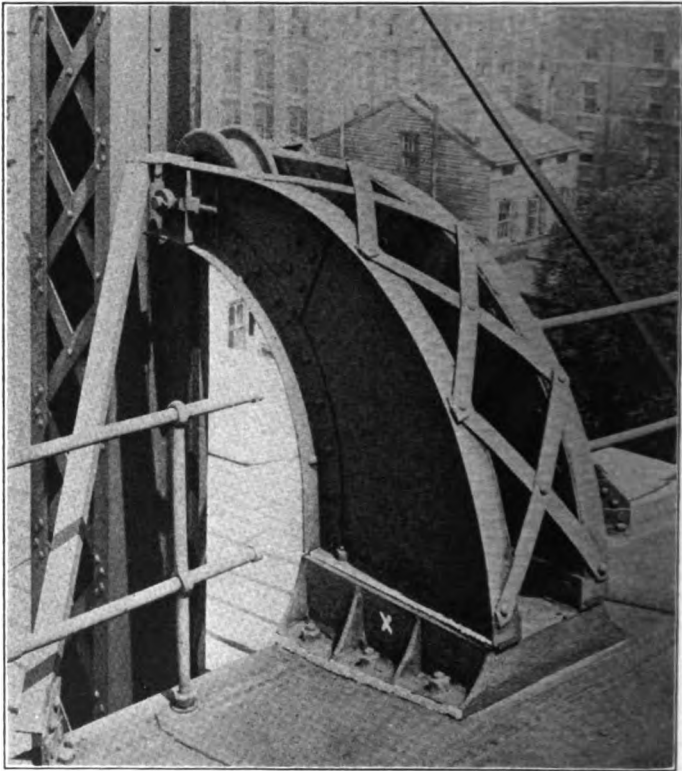


Fig. 11.—Enclosed carriage bed plate. Page 791.

were considerably wasted by corrosion. This condition is illustrated in Fig. 12 taken from a 5,000,000 cu. ft. holder built in 1903. When such weights remain in use, it would be well to carry them in a frame raised clear of the crown sheets.

Many of the older type holders, with stayed crowns, were

constructed with very light crown sheets. These light plates buckled between points of support, leaving a considerable area for the accumulation of water, dust, cinders, etc. A practice has been made by superintendents, or foremen painters, or whoever was responsible for the care of the holders, of attempting to fill these depressions with paint skins, or roofing cement, and thus allow the water to flow off. This was found to be a very dangerous practice, as moisture found its

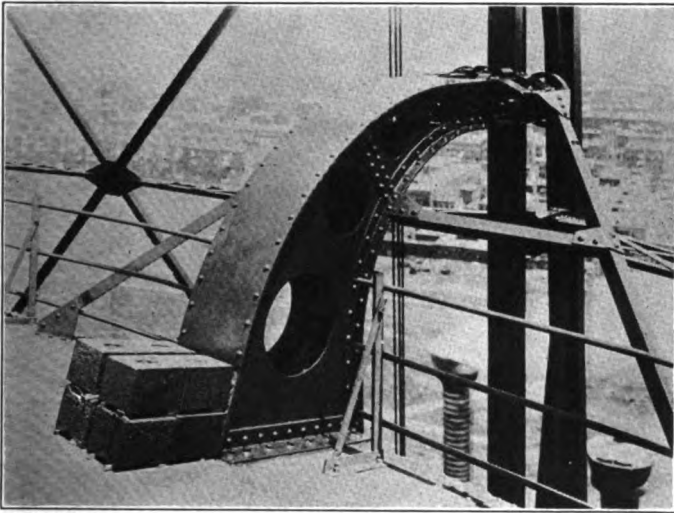


Fig. 12.—Counter weights removed from goose neck. Page 792.

way under the filler and crown sheets were found badly corroded. This condition is illustrated in Fig. 13, taken from a 500,000 cu. ft. holder, the date of erection not being available. These depressions should be kept clean and frequently painted.

### *Sections.*

One of the most serious conditions with which we have to deal in caring for the sections of modern holders is the manner in which the vertical legs or stiffeners were attached on holders built prior to 2 or 3 years ago. These legs, or stiff-

eners, are frequently formed of channels attached to the outside of sections by means of 2 angles. The inequality of surfaces to which they are attached caused by the overlapping plates is compensated for by thin fillers under retaining bolts. The spaces thus formed between the legs and the sheets of the sections harbor moisture and dust, and promote corrosion.

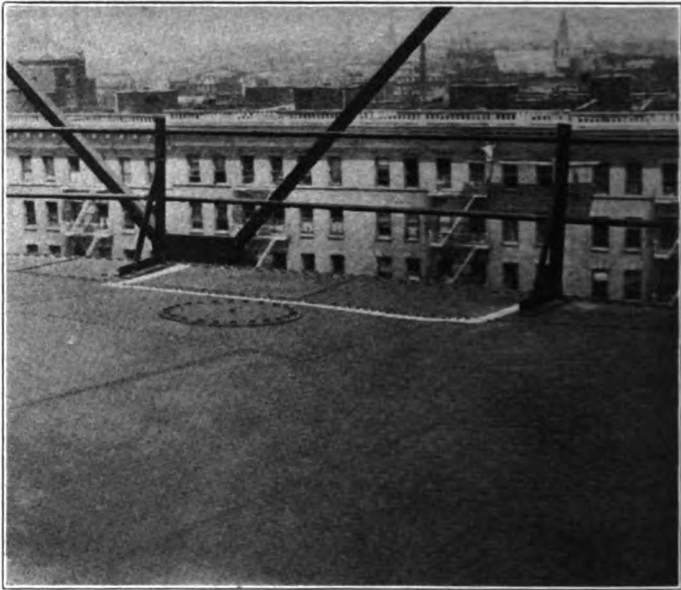


Fig. 13.—Corrosion at low spot in crown. Page 793.

This condition is illustrated on Fig. 14, which is taken from a 3,000,000 cu. ft. holder built in 1903. It is possible, in many cases, to clean these spaces by means of a thin scraper, and to paint the inner surfaces by means of strands of lampwick dipped in paint or red lead, and forced into the space with the scraper.

As a general proposition, the pockets and all places difficult of access on tanks, guide frames, and sections of holders should be freed of all roofing cement, putty, paint skins, or

any other filler, and thoroughly cleaned and painted, as none of the substances heretofore used have been found to entirely exclude air and moisture.

Wherever possible the drilling of drain holes in pockets will be found to largely prevent corrosion. This has also been found very effective in preserving footwalk plates, as these become slightly buckled and allow water to stand after a rain

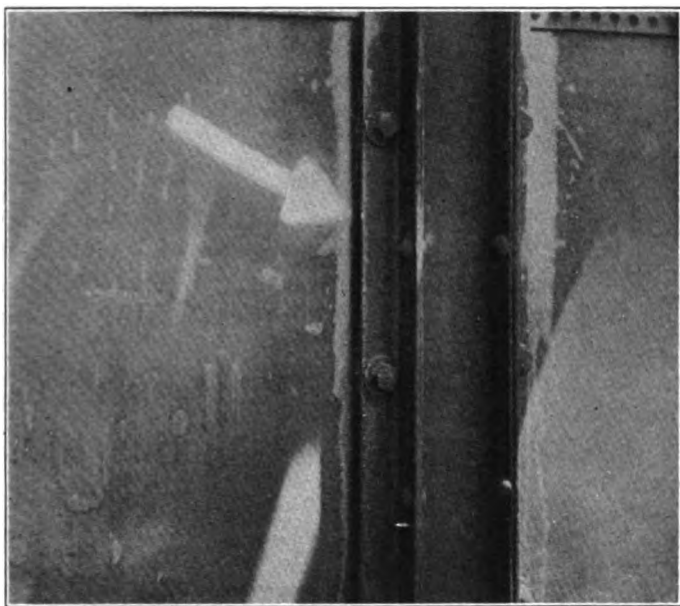


Fig. 14.—Space between vertical leg and section sheet. Page 794.

storm, which in the course of time evaporates, putting the metal to a severe test. These points can be easily observed and marked immediately after the rain, and holes drilled when the opportunity offers.

There are, of course, some cases where the pockets of frame work are so inaccessible that their filling with some sort of protecting compound is necessary in preference to having

them filled with water, dust, and cinders. In these cases, care should be exercised in selecting the compound to be used.

Inquiry by the writer develops the fact that at least one well-known paint manufacturer has upon the market a compound specially designed for water-proofing the decks of bridges, viaducts, etc., and which is of such a nature that cracks or breaks caused by abrasion, or the distortion of the structure to which it is applied, "heal" automatically, thus allowing the compound to resume its function of protecting the structure from air and moisture. Although this compound was designed primarily for use on railroad bridges there would seem to be some instances where its use on holder framing would be an advantage.

#### *Hand Rails.*

On many holders, hand rails will be found to be formed of ordinary gas pipe and fittings, supported by cast or malleable iron stanchions. In many instances, gas pipe hand rails have been found corroded away at the threads, which are sometimes cut to a great length to serve the purpose of unions or long screws when putting the rail together; and breakage of railing supports made of cast or malleable iron have occurred. In all such cases, it would seem advisable to replace railing supports with angles and form the rails of solid bars.

#### INSPECTION.

A thorough inspection of all parts of every holder, from tunnel to crown, should be made at least every 6 months, by those competent to pass upon their general condition. The character of individuals making these inspections will, of course, depend largely upon the organization and the size of the company, but where any considerable number of holders are under control of one engineer, it would seem that the inspection should be delegated to one man, whose sole duty consists in their care and maintenance. If such an individual is appointed, he should be a practical man, and should make preliminary examinations, reporting to his superior the details of his findings.

Printed forms of reports have been adopted by one of the larger companies, which are shown in Figs. 15 to 19 inclusive. These forms are furnished the inspector, and are printed on heavy manila paper, and bound in a canvas covered binder. The inspector makes his entries upon these blanks, and upon the completion of the inspection of any one holder, turns his

HOLDER INSPECTION REPORT		
WORKS STATION	HOLDER No.	DATE
TANK		
Bottom Curb		
Top Curb		
Sheets		
Guide Rails		
Overflow		
Stairway, Walls, Railing, etc.		
Inlet Pipe		
Outlet Pipe		
Standard Supports		
Skimmer		
Condition of Paint		
Water Supply		
Riveting		
Drip Pumps		
Water Pockets		
Tunnels		

Fig. 15. Page 797.

original copy into the office, where a copy is typed for an office record, which the holder inspector signs, after which he receives his original copy again for use in directing repairs.

After this preliminary report is made, the superintendent or engineer in charge makes a final examination of the special points brought to his attention, and passes upon the recom-

mendations for renewals, repairs, etc. The holder inspector can also have general supervision over repair and painting gangs.

In addition to this semi-annual inspection, inspection should

#### HOLDER INSPECTION REPORT

WORKS STATION	HOLDER No.	DATE
<hr/>		
<b>GUIDE FRAME</b>		
<hr/>		
Standards	<hr/>	
Struts	<hr/>	
Lateral Braces	<hr/>	
Horizontal Tie Struts	<hr/>	
Riveting	<hr/>	
Ladders	<hr/>	
Stairway	<hr/>	
Condition of Paint	<hr/>	
Level, etc.	<hr/>	
Buckling	<hr/>	
<hr/>		
<b>STEAM PIPING</b>		
<hr/>		
Covering	<hr/>	
Valves	<hr/>	
Unions	<hr/>	
Hangers and Supports	<hr/>	
Drains	<hr/>	
Jets	<hr/>	
Flexible Hose, Kind in use	<hr/>	
<hr/>		
<hr/>		
<hr/>		

Fig. 16. Page 797.

be made at stated periods of time to ascertain the general condition of holder structures, as to alignment, levels, etc. This examination should, of course, be made under the direct supervision of the engineer in charge, or his assistants.

Major repairs, such as renewal of distorted members, etc., will, of course have to be done by the holder builders.

#### MINOR REPAIRS, OVERHAULING, ETC.

Minor repairs, such as patching, caulking seams, drilling drain holes, sealing tank walls, adjusting rollers, etc., can be done very well by a small gang of skilled men in the company's employ.

#### HOLDER INSPECTION REPORT

WORKS STATION	HOLDER No.	DATE
FIRST OR INNER SECTION		
Crown		
Top Curb		
Hydraulic Cup		
Manholes		
Seal Bonnets		
Vertical Legs		
Top Carriages		
Top Carriage Braces		
Guard Rail		
Projecting Platform		
Condition of Paint		
General		

Fig. 17. Page 797.

As a general rule it is good practice to complete all minor repairs, overhauling, etc., of a holder just prior to its being painted. This procedure is carried even further by the writer's company and all cleaning of water pockets, and general renovating of the holder is done by a special gang before the painters come on the ground. This special work consists in cleaning out and red leading water pockets, drilling drain holes, removing putty, roofing cement, etc., from places which



can be cleaned and drained without the use of such compounds, pumping out and cleaning wells and tunnels, etc.

This general overhauling is found to effect an economy, as when the large painting gang arrives at the holder, their work is uninterrupted by the necessity of special attention to such affected parts.

It has been found necessary to equip these repair gangs with special tools to reach places difficult to access on frame work

HOLDER INSPECTION REPORT		
WORKS STATION	HOLDER NO.	DATE
SECTION		
Hydraulic Cup or Bottom Curb		
Hydraulic Grip		
Vertical Legs		
Grip Gallery		
Platform		
Top Rollers		
Bottom Rollers		
Top Carriage		
Top Carriage Braces		
Bottom Carriage		
Condition of Paint		
Inverted Cup Rollers		

Fig. 18. Page 797.

and sections. Figs. 20 and 21 illustrate these special tools. A description of their uses follows:

*Tool No. 1.*—For cleaning out pockets formed by junction of lattice bars and chord angles in the latticed type of standard supports.

*Tool No. 2.*—For cleaning behind vertical legs or stiffeners on sections, where space is  $\frac{1}{8}$  in. to  $\frac{1}{4}$  in.

*Tool No. 3.*—For same use as Tool No. 2 where space is  $\frac{1}{4}$  in. or more. Made long so as to give enough spring to reach all points behind the leg.

*Tool No. 4.*—For same use as Tool No. 2, where space is less than  $\frac{1}{8}$  in.

*Tool No. 5.*—General scraper for use on flat surfaces.

*Tool No. 6.*—General scraper for use in pockets.

*Tool No. 7.*—Cup scraper. Has pipe handle from 3 ft. 0 in. to 4 ft. 0 in. long, attached to scraper by means of coupling.

#### HOLDER INSPECTION REPORT

WORKS STATION \_\_\_\_\_ HOLDER No. \_\_\_\_\_ DATE \_\_\_\_\_

#### WATER LEVELS AND TEMPERATURES

Tank	1st Sec.		2nd Sec.		3rd Sec.		4th Sec.		5th Sec.	
Distance from top curb to surface of water	Temperature of Water	Depth of Water in cup	Temperature of Water	Depth of Water in cup	Temperature of Water	Depth of Water in cup	Temperature of Water	Depth of Water in cup	Temperature of Water	Depth of Water in cup

#### GENERAL NOTES

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Fig. 19. Page 797.

All the tools shown are, of course, used for a variety of purposes, but were made for the special use stated. Regular stock scrapers used by all painters are not shown.

Applying patches on plates, or replacing rivets in leaking seams with bolts, has been frequently touched upon, a very good and effective bolt being shown in the "Catechism of

Central Station Gas Engineering," issued by the Trustees' Gas Educational Fund.

A bolt which has been adopted by the writer with considerable success is shown in Fig. 22. Many engineers, however, prefer to use an ordinary split head tap screw, or resort to the method known as "fishing," *vis.* :

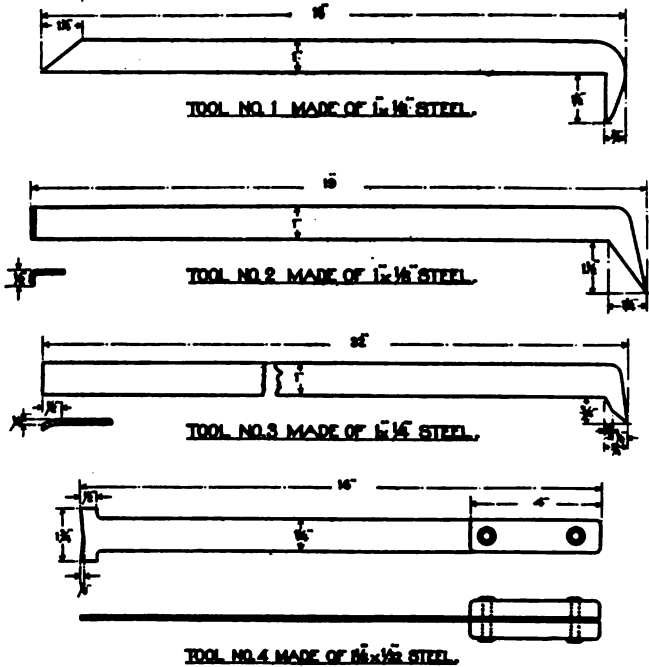


Fig. 20.—Repair tools. Page 800.

When repairs are made in the side sheets or crown sheets near the curb, to drop a line through the hole in which it is wished to insert a bolt and draw this line up under the bottom curb of the outer section by means of a long hook made of heavy wire; attach the bolt and draw the bolt into position with the line.

A similar method has even been resorted to in the case of leaks at rivets in steel tanks. The method in this case being

to drive out the rivet and force a float consisting of a sealed bottle or cork attached to a line through the hole, allowing this to float to the surface of the tank, where the bolt is attached to the line and drawn into position in the same manner

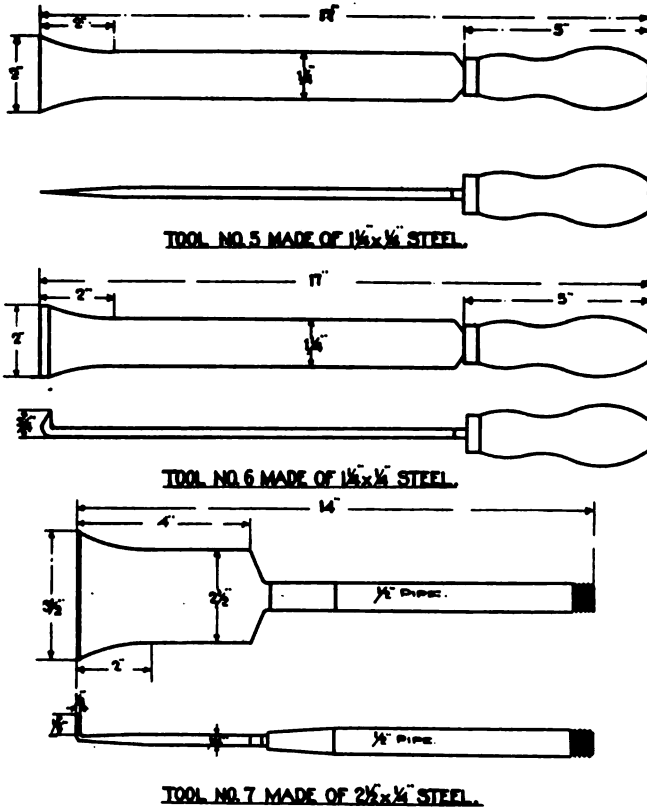


Fig. 21.—Repair tools. Page 800.

as in the case of the side or crown sheet repairs. The writer has not seen this done personally, but is assured by competent authority that it is a possibility. It is unnecessary to state that men engaged in this work wear water-proof clothing.

Before leaving the general subject of minor repairs and

overhauling, attention is called to the possibility of cleaning holders while in service with sandblast. There are now a number of concerns engaged in manufacturing apparatus for this purpose, and many contractors are equipped to do this work. While this method is expensive, there is a question in the case of holders which have been neglected or improperly painted and cared for, whether it is not the cheapest method in the long run.

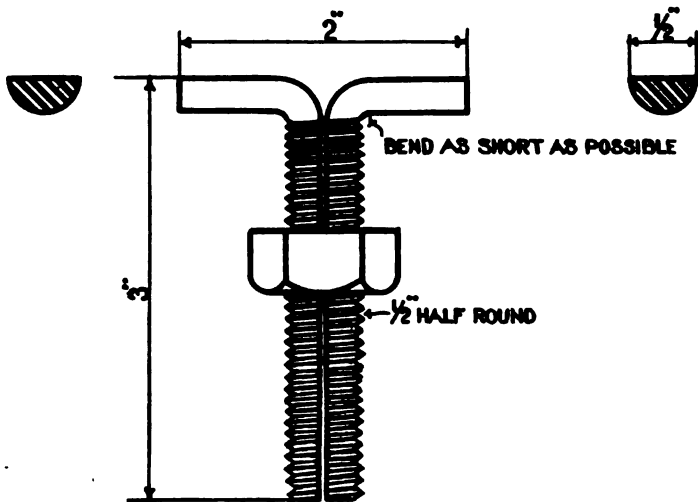


Fig. 22.—Repair bolt. Page 802.

It seems good practice to require that all tools used aloft should be provided with lanyards to secure them to the wrists or belts of workmen using them, as this may avert serious or fatal injury from falling tools to fellow workmen, or the general public. This, of course, cannot be made to apply to heavy tools, such as sledges and bars, which in falling might carry the man with them.

#### PURGING.

In cases where major repairs are to be undertaken, necessitating the landing of the holder and the purging out of the

remaining gas the following procedure would seem to be good practice:

1. Remove all oil from inner surface of tank water by means of skimmer permanently in place, or if no skimmer is provided, by the use of a temporary skimmer, the forms and uses of which are well understood. In the latter case, the holder will, of course have to be raised to its full height in order to introduce the temporary skimmer under the bottom curb of the outer section.

2. After all the oil possible has been removed from the surface of the water, the holder should be landed and all connections sealed, and one of the manhole plates removed. In place of this manhole plate, a similar plate should be installed, with a steam jet blower connected thereto. These blowers are made in various sizes and are inexpensive. They can be secured having capacities of from 10,000 to 2,000,000 cu. ft. per hour. A valve should be installed between this blower and manhole plate of the full size of the blower discharge. This valve should be kept closed until ready to raise the holder. An outlet closed by a blank flange and of the full size of blower discharge should be provided above the valve, the use of which will be explained later. The smaller sizes of blowers can be conveniently connected from permanent steam piping on guide frame by flexible hose, the regular top cup hose being in all probability sufficient for the purpose.

3. When this apparatus is in place, turn steam into the blower and allow the holder to rise as rapidly as possible. It is a wise precaution if metallic hose is used for this purpose to insert a nipple of rubber hose, not wire wound, between the blower and metallic hose to prevent any possibility of stray electric currents carried on the holder or guide framing arcing during the operation. There will be a time, of course, during this operation when an explosive mixture will be present in the holder, and air should be introduced as rapidly as possible while passing this point. The tabulation below is from the physical laboratory of one of the larger companies, and will serve as a guide to indicate when the danger point is passed:

## EXPLOSIVE PROPERTIES OF MIXTURE OF GAS AND AIR.

Gas, per cent.	Air, per cent.	Result
Up to 9	91	No explosion.
From 10 to 12	90 to 88	A very slight explosion.
From 13 to 14	87 to 86	A slight explosion
From 15 to 18	85 to 82	A hard explosion
From 19 to 20	81 to 80	A very hard explosion.
From 21 to 22	79 to 78	A hard explosion
At 23	77	A slight explosion
From 24 to 25	76 to 75	A very slight explosion.
From 26 upwards	74 downwards	No explosion.

*Summary.*

Mixtures began to explode when they contained 10 per cent. gas and 90 per cent. air. Explosions increased in strength until a maximum at 19 per cent. gas and 81 per cent. air. They then decreased in intensity until the mixture contained 26 per cent. gas and 74 per cent. air, when the explosions ceased.

The above experiments were made under laboratory conditions. In actual practice, when purging a holder, especially if steam is used, oil vapors will be found to form, which will explode when the percentage of air is higher than at any point noted in the test. The writer has exploded mixtures containing as high as 93 per cent. to 94 per cent. of air.

When it is certain that the explosive point is passed, it is well to continue the air injection as long as possible, in order to reduce the odor in the neighborhood to the minimum when the air is purged from the holder. Calculations of volumes of gas and air should not be depended upon as an assurance of the non-explosive character of the contents of the holder, but will serve to indicate when dangerous mixtures are to be expected. Analyses and explosion tests of the contents should be made at frequent intervals. Samples for this purpose should be taken from a number of points on the crown of the holder. Upon reaching this point, the steam may be shut off from the injector and the air allowed to purge back through the outlet provided above the valve, which has been protected by double gauze, 1 ft. apart and 900 meshes to the square inch, the descent of the holder being controlled by valve already

referred to. The air intake in the blower should be closed by a blank flange during this part of the operation. This procedure should be repeated a sufficient number of times to insure any remainder of gas, or mixture of gas and air, being diluted and purged out.

4. After the holder is landed, a second plate should be removed upon which is installed a sheet metal purging pipe, equipped with gauze as heretofore described, and either connecting with a canvas duct running up holder frame, or if the holder is in an isolated neighborhood, the metal purge pipe can be carried only sufficiently high to be out of the reach of workers on the holder. Steam should now be turned into the injector again and the crown of the holder purged until it is sufficiently free from gas to allow of the work proceeding. Trouble will probably be encountered at this point, from the fact that oil vapors will form from residue of oil on top of tank water, all of which it is impossible to remove by skimming. If it is found that this vapor continues to form after a considerable period of purging, it will probably be found necessary to introduce live steam at several points on the holder, the steam in the course of time carrying off the oil by evaporation.

5. The tank can now be pumped out and the sludge removed from the bottom. This will probably be found to give off a strong odor and some vapor, and great care must be used in allowing men to enter the holder before assurance is had that there is sufficient pure air present to support life.

#### PAINING.

“ . . . Various attempts have been made to prevent the decay of iron and steel, such as immersion in an alkali solution, which is but temporary, as upon its emergence it is again subjected to decaying influences; another temporary method is a treatment with chromic acid. All of this is but an attempt to alter the nature of steel and iron, which up to to-day has been found impossible, and the only other alternative is to protect the



metal from such causes as induce electrolytic action, or decay, by covering it with some material which in itself will not induce electrolytic action in the metal, and which will prevent the contact of moisture with the metal itself.

"It is not my intention to advocate any particular paint or covering, but I will point out the virtues necessary to a good protective paint.

"The first coat applied should form a hard foundation, and should possess adherent qualities in favor of the succeeding coats, as if the first coat should be soft the succeeding coats will crack, and if it should not be adherent, the succeeding coats will peel off.

"This covering should also be a non-conductor of electric currents, as in order to prevent the electrolytic action described above, it must be capable of opposing the admission of those outside influences which will cause an electric current to pass through or over the surface of the metal. The constituents of the covering in themselves should be inhibitive of corrosion, in that they should negative the action of the molecules in the metal which tend to produce electrolytic action.

"The constituents should also be such, that none of them are soluble in water, for if this is so, the paint will soon disintegrate, or upon dissolving they might form other compounds in the cup or tank water which might accelerate electrolytic action.

"It should also be impermeable, as if it is porous, and moisture finds entrance into the body, the means for producing corrosion are immediately at hand." . . .

It is perhaps not too broad a statement to say that a considerable portion of the deterioration of modern holder structures is due to the perfunctory nature of the painting and lack of care in selecting paint, red lead, oil, etc. Unskilled labor has also contributed largely to the failure of paint to properly protect the surface to which it is applied. The late Mr. Charles L. Rowland pointed out the danger to holder structures of improper painting in a paper entitled,

"Gas Holders, Their Care and Operation," read at the Seventeenth Annual Meeting of the American Gas Light Association, October 16th, 1889.

As a general rule, it will be found that painters in the employ of the gas company, and under the direction of a skilled foreman, will save the company money in the long run. Contractors will usually take a painting job cheaper than it can be done by the company's employees, but they naturally have not the same interest, and it is quite impossible to compel them to exercise the same conscientious care that will be given by a company's employee to whom the result attained is more to his credit than the completion of the work for a stated sum.

In taking up the general subject of painting, I cannot perhaps do better than quote from an article by Mr. F. P. Cheeseman, appearing in the Fortieth Anniversary number of *The Painters Magazine*, May, 1914, entitled, "Structural Steel Coatings, the Development of Protective Paints for Metal Surfaces."

"A greater advance has been made in technical paint knowledge during the last ten years than ever before in the history of the trade. This has been due largely to the experiments conducted under the auspices of the various associations, such as the Paint Manufacturers, The American Society for Testing Materials, The Society of Chemical Industry and others. We will state briefly a few of the leading results announced . . .

"The quality and construction of structural iron or steel used to-day, is quite different from that originally used, and this has necessitated a change in the composition of paints suitable for use on such structural metal.

"One thing must be remembered, and we quote Emil Swennsen, M. Am. Soc. C. E., as one of the best authorities on this, and that is: "That on some steel it is impossible to get anything that will stand, as the steel will eat up and destroy any protective coating that can be applied, and the paint that stands so well on one structure will

go to pieces on another, simply due to this cause, and it should not be blamed for its quick destruction.'

"It has now been proven that it is impossible to make a standard paint formula that will suit all climatic conditions, hence to obtain the best results the paint should be made to order to suit the location, time of year, and the character of the work . . .

### *Spreading Power.*

"On a surface which does not absorb any of the paint, you can approximate the average thickness of a coat in the following manner:

"The liquid standard U. S. gallon contains 231 cu. in. and if one gallon of paint is spread over a smooth metal surface containing 231 sq. ft., the paint will average 1-144 ins. thick.

"In like manner, should the paint be spread twice as far and cover 462 sq. ft. to the gallon, it would be 1-288 in. thick, which thickness can be compared to the thickness of the leaves of a book having 576 pages to the inch.

"There is, of course, a limit to the proper spreading power of a paint, and when you go beyond 800 to 850 sq. ft. per gal. you are doing so at the expense of durability, as you must have sufficient percentage of pigment to the sq. in. of surface to properly protect the vehicle from decay . . .

### *Priming Coats on Metal.*

"The most important fact that has been brought out by the various tests is that poor results are obtained by using a graphite or carbon pigment paint for priming or shop coats, and it is now generally conceded that graphite or carbon are stimulators of corrosion when used next to the bare metal, but when used as finishing coats over a selected priming coat good results are obtained. The best pigments for priming coats are as follows: Red oxide, and metallic brown pigments of selected grade, red lead, blue lead, and magnetic black oxide.

"The author has contended for years that a hand-mixed dry red lead could not be properly mixed and applied by a painter, as an uneven coating would be given. In some places too much pigment, and in others practically no pigment at all, only the vehicle. The lead companies have now apparently recognized this fact and recommend the use of a paste red lead. It would be very much better if they took one step further and recommended the use of ready mixed red lead containing about 75 per cent. of red lead, the balance selected inert pigments, and the vehicle pure linseed oil with a small percentage of selected drier. . . .

#### *Vehicles.*

"There is quite a difference in opinion as to whether to the oil or the pigment is due the life of the paint. In our opinion to neither one can be given the entire credit, but the life or the durability of the paint is due to the proper combination of the two. . . .

"The oil vehicle should be a selected, well aged linseed oil, and in most cases greater durability is obtained by using raw linseed oil in preference to boiled. . . .

"There is not in use at the present time a paint vehicle that will permit of a permanent protective painting compound being produced. Linseed oil is not the ideal vehicle, but nothing better as yet has been discovered, for universal painting requirements, but for some locations other oils, such as Chinese wood oil and treated fish oils, can be used to advantage.

#### *The Painting of Steel Bridges.*

"The question of durability regarding the painting of steel bridges is not so much a question of season as it is a question of favorable weather. So far as temperature is concerned, either extreme (hot or cold) is equally detrimental to paint. Extreme heat forces paint to dry rapidly and therefore unnaturally, while extreme cold retards the drying and consequently also causes unnatural

drying. . . . When an oil paint dries naturally it absorbs the requisite amount of oxygen, but if forced by extreme heat, or by the addition of artificial driers, its durability is correspondingly impaired.

"When it becomes necessary to scrape away or sand-blast the structure, thus exposing the bare surface of the metal, the cleaned surface should in no instance be left unprotected over night, or for a period sufficiently long to absorb moisture, but should be followed up immediately with painting.

"To find the amount required to paint the structural iron of a bridge or building, take the estimated weight, for instance, of the framework of a building of 450,000 lbs. of an average thickness of 5/16 in. A square foot of 5/16 in. iron weighs 12.75 lbs. Divide the total weight, 450,000 by 12.75, equals 35,300 sq. ft. one side. As both sides are to be painted, double this, making 70,600 and add 5 per cent. to cover top and bottom, equals about 74,000 sq. ft.

#### *Painting Steel Imbedded in Concrete.*

"For some years it has been the opinion of civil engineers that structural steel imbedded in concrete should not be painted; they being of the impression that the concrete is a protection against corrosion. Within a recent period, however, it has become a recognized scientific fact that structural steel imbedded in concrete should be protected with a paint coating, because in many cases it has been found that corrosion set in on the steel, and the concrete was forced away from the steel by rust, thereby causing cracking and destroying the strength of the bond between the concrete and the steel. It is also a well known fact that the lime contained in concrete will quickly destroy linseed oil paints. It is, therefore, recommended that steel which is to be encased with concrete should first have a priming coat applied to the bare metal of a high grade linseed oil oxide of iron paint, and

over this should be applied at least one, or preferably two, coats of a paint specially made for coming into contact with concrete, which paint should not contain any linseed oil. The up-to-date steel engineer is now specifying the use of such a combination."

The references in the first part of Mr. Cheeseman's article, to experiments conducted under the auspices of various associations, refer no doubt in part to the paint tests conducted at Havre de Grace on the Pennsylvania Railroad bridge spanning the Susquehanna River, and to the tests of single pigments on the steel test panel fence at Atlantic City. Detailed reports of the committees conducting these tests will be found in the *Proceedings* of the American Society for Testing Materials, from 1909 to date.

The society has also published in one volume the "Reports of the Committee on Preservative Coatings for Structural Materials, 1903 to 1913," in which will be found a great quantity of data on paints of all descriptions.

The results of the Havre de Grace tests are very confusing, and it is doubtful whether they are valuable to any but the manufacturers themselves, who know definitely of what the various paints are compounded. One fact, however, seems to be established by the tests and that is that paints, the pigments of which are largely composed of red lead, wear better during a practical test of this nature than any of the other paints submitted. Even this statement must be qualified to the extent of saying that the manner of compounding these paints is unknown, and the nature of the other substances incorporated with the red lead has not in all cases been made clear.

The conclusions drawn from these experiments must be that it is practically impossible to derive any information of value for general use from exposure tests made with commercial mixed paints, the formulae for which are not available.

The Atlantic City steel panel experiments were undertaken in order to check laboratory data which tended to indicate

the sub-division of pigments into classes based upon their value as preventers of corrosion. Some of the results seem to bear out the laboratory findings, and it is probable that paint tests in the immediate future will be confined to experiments with single pigments or paint compounds, the constituents of which are known to the experimenters. It is to be hoped that valuable data will, in the course of time, be forthcoming as a result of the vast amount of work done by those conducting these various experiments. In the meantime, it seems we are left to our own resources in selecting paints for holder coatings, but it seems safe to say that those of us who are using a red lead priming coat and either iron oxide, red lead, or carbon paints, for a finishing coat, are at least on the conservative side.

It is also probably safe to say that the vehicle of all paints, both priming and finishing coats, should be of pure linseed oil, with the exception of paints to be submerged. A number of proprietary articles are offered as substitutes for red lead or oxide, as a priming coat for steel, and several of them are doing very well under exposure tests, but the length of time to which they have been exposed, under the writer's observation, is not sufficient to warrant an opinion at this time. As it is probable that there are a number of us using, and will continue to use for some time to come, red lead as a priming coat, it is interesting to note that the chief difficulty in the use of red lead has been removed within the past year or two, as red lead can now be secured ground in oil containing approximately 97.8 per cent. of pure red lead and which will not "set up" if exposed to the atmosphere and not immediately used.

In the work by Cushman and Gardner referred to above, a tabulation is given showing moisture penetration tests of paint films; that is, the power of various paint films to exclude moisture. In these tests, iron oxide stands first; white lead, second; red lead, eighth; with carbon and graphite well down the list.

If these experiments are taken to be at all conclusive, which, by the way, the authors do not claim, it will be of interest to those of us who have been using an iron oxide finishing coat to note that iron oxide is classed as the best excluder of moisture, without which no corrosion can take place in any case.

### *Tests of Paints.*

The best test that can be made of paints destined for use on exposed structures is, of course, a practical test, upon a portion of such structure. Many other tests are resorted to in an endeavor to hasten the porcess of nature, but I do not think that anyone will claim that valuable results are derived therefrom. It is not possible to even determine definitely that samples of certain paints furnished are exactly similar to those previously examined. It is, however, a wise precaution to send samples of all mixed paints, red lead, white lead, and linseed oil to the laboratory, as any shortage in the desired ingredients in the pigment, or gross adulteration of the vehicle, or the use of driers, detrimental to the life of the paint, will be determined, and will be sufficient grounds for rejecting the shipment.

In general, it can be safely said that anyone using a paint which appears to be fairly uniform in composition, and which has furnished in the past adequate protection to the structure on which it was applied, should continue to use such a paint and not conduct experiments which may be costly and embarrassing. Assurance should be had, however, that the manufacturer furnishing the paint is reliable, and will not change its composition without your knowledge, or, in other words, will not experiment at your expense. Before leaving the general subject of the composition of paint, it might be of interest to note the following analyses of paints, which have been used to the writer's knowledge during 5 or 6 years, all of which have given good service. The wide variation shown in the composition of these paints bears out the statement that we have still much to add to our knowledge of paint products.



## RED HOLDER PAINT NO. 1.

*Analysis of Pigment.*

	Per cent.
Calcium carbonate .....	65.79
Iron oxide, $\text{Fe}_2\text{O}_3$ .....	22.90
Silica, $\text{SiO}_2$ .....	4.40
Loss on ignition .....	4.46
Undetermined .....	2.45
	<hr/> 100.00

*Analysis of Vehicle.*

The vehicle consists of linseed oil, containing 24.83 per cent. of mineral oil. There is present also some organic dye which prevents the determination of the constants of the linseed oil, by imparting a reddish color to the oil. The dye was extracted with alcohol and the extract used to color the annexed piece of cotton cloth. This dye is not soluble in water, and if the paint were exposed to the rain, the color caused by the dye would not probably be washed out.

## RED HOLDER PAINT NO. 2.

*Analysis of Pigment.*

	Per cent.
Alumina, $\text{Al}_2\text{O}_3$ .....	1.90
Calcium oxide $\text{CaO}$ .....	1.14
Iron sesquioxide, $\text{Fe}_2\text{O}_3$ .....	63.74
Magnesium oxide, $\text{MgO}$ .....	0.77
Silica, $\text{SiO}_2$ .....	19.62
Sulphur trioxide, $\text{SO}_3$ .....	0.43
Loss on ignition .....	4.88
Undetermined .....	7.52
	<hr/> 100.00

This pigment is probably a variety of natural bright red oxide.

*Analysis of Vehicle.*

	Per cent.
Acid number .....	4.12
Iodine number .....	165.3
Hexabromides .....	28.18
Saponification number .....	190.38
Specific gravity at $15.5^\circ \text{C.}$ .....	0.941

This vehicle is linseed oil.

## RED HOLDER PAINT No. 3.

*Analysis of Pigment.*

	Per cent.
Alumina, $\text{Al}_2\text{O}_3$ .....	4.20
Calcium sulphate, $\text{CaSO}_4$ .....	31.16
Iron oxide, $\text{Fe}_2\text{O}_3$ .....	31.02
Silica, $\text{SiO}_2$ .....	12.28
Organic matter and water—by difference.....	21.34
	<hr/>
	100.00

*Analysis of Vehicle.*

Acidity .....	1.24
Hexabromides .....	53.3
Iodine number .....	165.7
Saponification number .....	197.4
Specific gravity at $15.5^\circ \text{C}$ .....	0.9365

This is a good sample of linseed oil; does not contain any turpentine, rosin oil, or fish oil.

## RED OXIDE PAINT No. 4.

*Analysis of Pigment.*

	Per cent.
Alumina .....	3.50
Calcium .....	1.07
Iron oxide .....	92.00
Silica .....	0.82
Loss on ignition .....	2.55
	<hr/>
	99.94
Pigment .....	57.66
Vehicle .....	43.34
Specific gravity of vehicle at $60^\circ$ .....	0.9450

## GREEN HOLDER PAINT No. 1.

*Analysis of Pigment.*

	Per cent.
Soluble alumina, $\text{Al}_2\text{O}_3$ .....	2.94
Barium sulphate, $\text{BaSO}_4$ .....	40.62
Calcium sulphate, $\text{CaSO}_4$ .....	18.55
Combined water, $\text{H}_2\text{O}$ .....	2.68
Insoluble silica, $\text{SiO}_2$ , and alumina, $\text{Al}_2\text{O}_3$ (clay)..	11.98
Lead chromate, $\text{PbCrO}_4$ .....	9.49
Prussian blue, $\text{Fe}_7(\text{CN})_{14}$ .....	13.45
Undetermined .....	0.29

*Analysis of Vehicle.*

Acid number .....	5.48
Iodine number .....	162.0
Linseed oil .....	88.54
Rosin oil .....	Present
Saponification number .....	198.7
Turpentine .....	11.46
Unsaponifiable number .....	2.16
Specific gravity .....	0.9246

## GREEN HOLDER PAINT No. 2.

*Analysis of Dry Pigment.*

	Per cent.
Alumina .....	1.94
Calcium carbonate .....	1.22
Chromic oxide .....	43.42
Ferric oxide .....	1.78
Insoluble matter .....	8.70
Lead chromate .....	40.43
Moisture .....	1.04
Nickel oxide and magnesia.....	Trace
Zinc oxide .....	0.73
	<hr/>
	99.26
Pigment .....	63.57
Vehicle .....	36.43
	<hr/>
	100.00
Specific gravity of vehicle at 60° F.....	0.9532

*Application of Paint.*

The most important item to be considered in applying preservative coatings to metal is to have the surface thoroughly cleaned (which has been covered in the foregoing paragraphs) and free from moisture. Second in importance only to this, is to have the paint film of sufficient thickness to assure a good wearing body, and not sufficiently thick to cause crinkling, creeping, or cracking. This latter result can only be accomplished by the employment of experienced painters, under competent direction. No painting should, of course, be done in damp or freezing weather, nor late in the day or

early in the morning, especially in the spring and fall, when marked changes of temperature and atmospheric conditions take place at this time of the day.

There is but one way, of course, in which to apply the paint to the guide frame, and that is from swinging scaffolds. The type of scaffold it seems wise to adopt is one having a guard rail completely enclosing and protecting the men working thereon. Such a guard rail is easily applied to the ordinary painting scaffold. There has been a question raised whether some type of safety block should be used in connection with painters' scaffolds. Many such blocks are on the market, some of which are released by shifting the position of the fall from a spiral groove on one side of the sheave to the regular groove on the other side of the sheave; others are made to be released only by tension on a particular line attached to the upper block. Many engineers are opposed to the use of any of these types of blocks, owing to their fear that the strands of rope may be damaged by the retaining mechanism. It would be well for all interested to look carefully into this matter, as improvements are constantly being made in such safety devices.

There are two methods of painting the sections of a holder, both of which have been used extensively, and have their strong adherents:

One of these method is to keep the holder at its normal duty and paint the entire surface of sections from swinging scaffolds.

The other method is to lower the holder until the upper sheets of the inner section are accessible from the tank walk, applying the paint as the holder rises. An objection to this method, although cheaper than the former, is raised that there is danger of painting the sheets before they are thoroughly dry. This objection is overcome by one of the larger companies by mounting the painters on trestles installed on the tank walk, thus allowing them to paint several sheets above those emerging from the water, and giving more time for

the drying of the sheets below, before it is necessary to paint them.

On holders of more than one section, there is difficulty in installing such trestles, due to the uneven surface presented by the various grip channels or grip galleries of the sections when landed. This is compensated for by the use of horses, two legs of which are made adjustable, and rest upon the grip channel or gallery of the innermost section landed.

There would seem no question about the economy of this method of painting, and it can be easily adopted in the case of smaller holders, and in many cases of the larger ones, where the holder capacity is sufficient to allow of this temporary curtailment of stock on hand.

The organization of a painting gang should comprise the supervision by a foreman, or sub-foreman, of every ten painters. These can be conveniently divided when the work starts into a scaffold gang, a gang for cleaning out, scraping and red leading cups, and a gang for painting carriages, goose necks, etc., and places so difficult of access as to cause costly delay to the main gang. Each one of these groups should be under the direction of a foreman or sub-foreman and still another competent man should be detailed to mixing, preparing, and issuing paint, oil, red lead, supplies, brushes, etc., in order that the foreman's time may not be taken from the main work in hand.

In painting steel tanks, care must be taken that such painting is not done at a time of the year when the air is warmer than the tank water; otherwise, the surface of the plates will be damp, and the paint will fail to adhere to the metal, requiring re-painting in a very short time. It has been the writer's observation that in this climate the water in the tank does not take the temperature of the air before the first or middle of August, after which time tanks can be painted with safety.

The brushes that have been found the most convenient for holder work of all descriptions are shown in Fig. 23. All are

trade brushes except No. 4, which is a specially made brush, with bristles in cylindrical form for painting narrow and deep

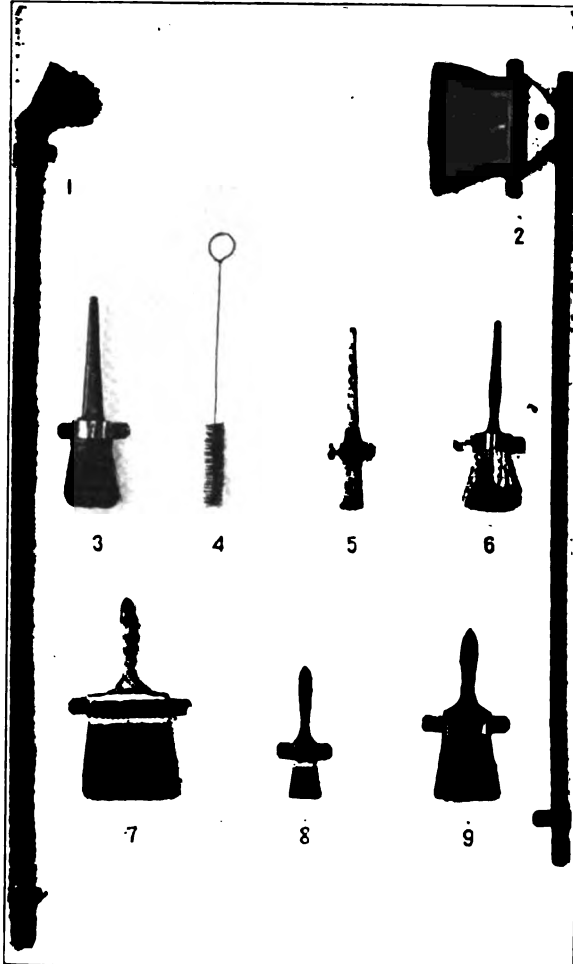


Fig. 23.—Brushes for holder painting. Page 820.

pockets formed by overlapping plates, abutting members, etc.

*Brushes Used For Holder Painting.*

- No. 1.* Long Handle Tar Brush.—For painting cups and pockets in frame work and bottom of carriages.
- No. 2.* 3 Knot Roof Brush, with Handle.—For painting crown of holder.
- No. 3.* No. 225 Round Brush.—For painting frame work.
- No. 4.* 1¼ in. x 5 in. Wire Handle Brush.—Use described above.
- No. 5.* No. 6 Stencil Brush.—For stenciling scale on holder.
- No. 6.* No. 2 Painter's Duster.
- No. 7.* 5 in. Wall Brush.—For painting shell and frame work.
- No. 8.* 1½ in. Brush, Set in Rubber.—For painting ends of lattice bars in column supports, etc.
- No. 9.* 3 in. Brush, Set in Rubber.—For painting carriages and wheels.

**HEATING, STEAM.**

The writer is advised that in certain parts of Europe, where the temperature ranges are as low as, or lower than here, no effort whatsoever is made to prevent water seals and tanks of holders from freezing, and no damage to or interruption of service of holders occurs. However, as we have not reached such a degree of temerity regarding the care of our holders, the current practice regarding the warming of water in seals and tanks will be discussed.

As a general rule, steam piping should be installed upon the holder in such a manner that ample provision is made for expansion and contraction, and no part of the frame work, railings, etc., is touched by or enclosed in the pipe covering.

*Main Lines.*

There are two general methods of installing the main steam lines to holders; one, underground; and the other, over head.

The advocates of the underground system claim less damage to steam covering from weather conditions in general, and falling snow in particular, and the more slightly appearance of the holder structures, when kept free from horizontal piping. There is still another point in favor of the underground lines, if laid deep enough below the frost line, and that is, the freedom from freezing of the horizontal lines, due to slightly leaking steam valves, when the lines in question are not required and are presumably shut off.

If underground lines are resorted to, the following method of covering them has given good service:

First, a regular magnesia, asbestos, or air cell sectional covering, over which is applied a wrapping of  $\frac{3}{4}$  in. hairfelt, which in turn is protected from moisture by builders' paper, or tar paper, the whole being enclosed in canvas covering, with the seam on the bottom.

Forms are then constructed, allowing several inches of space around the pipe covering, and these forms filled with concrete. The expansion and contraction is compensated for by steam loops or bends, which are not covered, and are enclosed in brick or concrete pits with waterproof head and covered with sawdust, ground asbestos, or any other insulating material, which will allow free movement of the bend. The pipe will be found to move freely inside of the covering without destroying the outer concrete envelope. Where possible, the valves controlling such underground lines, should be placed inside the wall of the building through which pipe penetrates and pitch should be toward such building, in order that no provision may become necessary for drains and steam traps underground. Where such method of draining is not possible, however, a trap receiver and steam trap can be located conveniently in the pipe tunnel, directly under the valve house floor. As condensation will be heavy during the cold weather, regardless of the position of the steam pipe, whether underground or overhead, trouble has been experienced with valves, etc., of steam traps which are subjected to such constant



duty. The writer has used a trap receiver and its accompanying trap as shown in Fig. 24, with very good results. A brief description of the manner in which this installation functions follows:

The combination of trap and receiver was devised to overcome the constant dumping of the trap, with consequent wear-

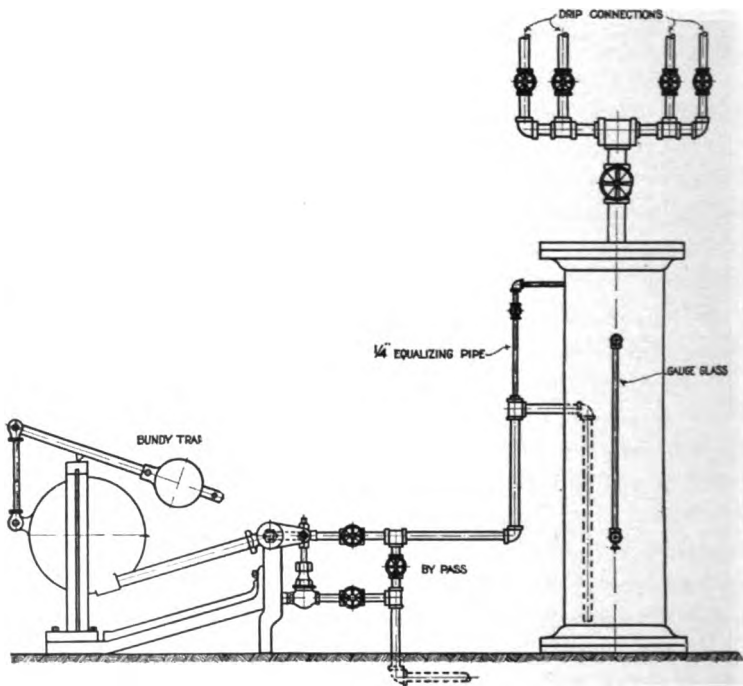


Fig. 24.—Steam trap and trap receiver. Page 824.

ing of its working parts resulting in leaks and high maintenance charges.

The type of trap shown is particularly valuable for the service owing to the fact that its working conditions may be determined at any time by a casual inspection, even by an inexperienced workman. It has been found that the substitution

of soft valve discs gives better results than the hard discs as supplied by the manufacturers.

The receiver consists of a piece of 12 in. standard pipe, 4 ft. 0 in. long, equipped with 12 in. extra heavy flanges. It will be seen that the drips connect into a manifold, which in turn is connected to the receiver. A valve is installed in this line, so that repairs, etc., may be made to the receiver. The discharge line is tapped into the receiver at a point 2 ft. 6 in. from the bottom. By connecting the pipe at this point, about 65 per cent. of the volume of the receiver is available for storage purposes, and the remaining 35 per cent. gives additional capacity to the receiver, in the event of trouble with the trap, or in case large quantities of condensation have to be disposed of momentarily. A gauge glass is installed on the receiver, and by reference to the glass it can be ascertained if the system is functioning properly. The discharge line extends in the interior of the receiver to a point within  $\frac{1}{2}$  in. of the bottom.

It will be noted that a  $\frac{1}{4}$  in. equalizing pipe connects the discharge line to the receiver. This is very essential, as without this pipe, the trap will dump when the lower end of discharge line becomes sealed in the condensate.

A number of these installations are giving excellent service.

It would seem, notwithstanding the arguments of advocates of underground steam piping, that the most convenient and economical method would be to keep steam lines, wherever possible, overhead and accessible at any and all times. The writer's practice has been to carry the main feed line to the holder, inside the building to the most adjacent point to the holder to be supplied, carrying the pipe through the wall of the building and across the intervening space, supporting it by means of truss rods or hangers, if necessary. The horizontal line on the holder is hung from standards and diagonal braces, leaving all parts of the pipe free, to take up the expansion and contraction. The method of covering these overhead lines is identical with that described for underground work, up to the

point where the concrete is applied. This method has been found to give adequate protection, and very little damage has occurred from falling snow, certainly not sufficient to warrant placing the lines underground, were this the only reason for doing so.

In applying canvas covering on lines exposed to the weather, care should be taken to have the seams formed on the lower side of pipe. This is not as convenient a place to work as on the top or sides, and pipe coverers will make the seams in the latter places unless carefully supervised.

### *Risers.*

There are also two distinct methods of installing the risers supplying the various cups.

The first method is to erect a single riser of sufficient size to supply all the cups, reducing this in size as the various branches for cups are taken off. This makes a very neat and inconspicuous installation and is cheaper to erect, the argument against it being the necessity of shutting off all the cups above the point of a possible break, and the greatly increased danger of syphoning the upper cups into the ones below in the case of the accidental shutting off of steam, or careless handling of the valves by those in charge. The writer very much prefers a separate riser for each cup, each riser covered separately in the manner described above. The controlling manifold for such a riser system which has given satisfaction is illustrated in Fig. 25. The suspender rods are provided to take the weight of the riser and prevent the breaking of the horizontal nipple at the base, and provides separate adjustment for each riser.

A very durable, if somewhat high first cost, method of covering holder steam lines has been adopted by one of the neighboring companies, and consists of protecting sectional pipe covering by means of copper or galvanized iron sheathing, which is made in sections, 2 or 3 ft. long, and secured by longitudinal flanges connected by bolts, the laps of the different sections being downward in the case of vertical pipes.

*Steam Hose.*

Of late years, metallic hose has been used extensively as a medium for conducting steam from the rigidly secured riser on the holder frame to the cups of moving sections. The ad-

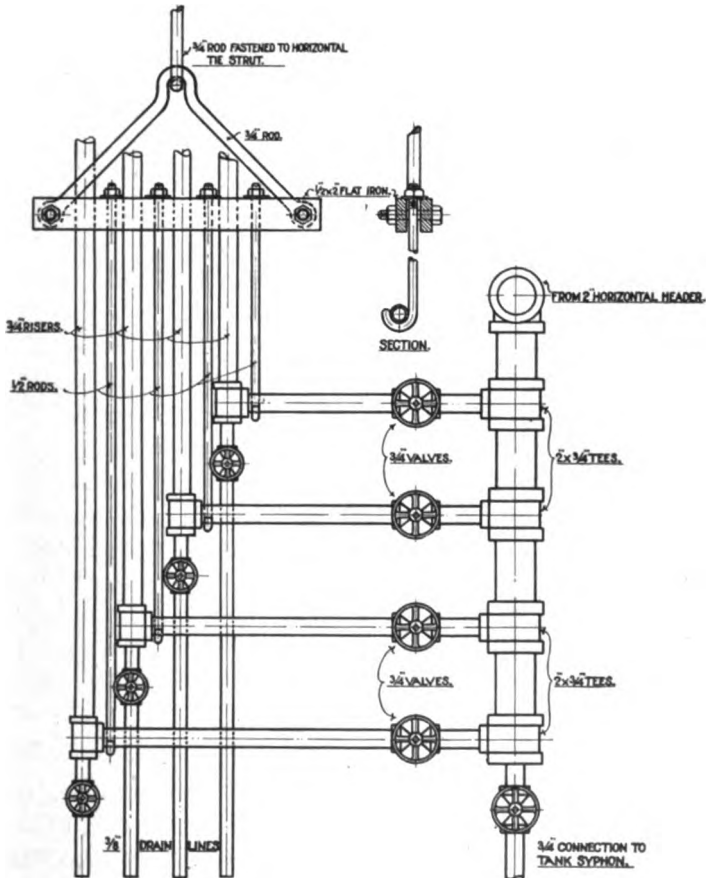


Fig. 25.—Arrangement of cup risers. Page 826.

vantages of metallic hose over rubber would seem to be as follows:

1. Greater strength.

2. Consequently, less liability of freezing or syphoning cups by reason of broken hose.
3. Less loss by radiation. Due to the possibility of more effective insulating covering being applied to metallic hose, without it becoming unwieldy.
4. Less rapid deterioration.

The length of time which metallic hose will last is, I believe, still an open question, as that purchased within the last 3 or 4 years is still in service and shows no signs of failure.

The disadvantages of metallic hose, as compared with rubber, are as follows:

1. Greater difficulty in repairing, when breaks occur.
2. Greater liability of its injury through careless handling, such as crushing, bending too short, etc.
3. High first cost, and high cost of maintenance.
4. Greater weight.

The woven covering which is now generally applied to this type of hose, requires replacing about every second year, the cost of which is about equivalent to new rubber hose. This latter factor makes it necessary for the life of metallic hose to be prolonged over a considerable period, in order to make it more profitable to use than rubber hose. It would seem as if the probable advantage derived from the use of metallic hose up to date is the increased security against freezing or syphoning cups, due to broken or disconnected hose, and reduced labor account for repairing constantly breaking rubber hose.

#### *Tank and Cup Jets.*

After a number of seasons' experiences with the syphon type of jet, the writer is of the opinion that they are very much more economical with steam, because of the better circulation of the water than with the plain type of jet, where live steam is admitted directly to the water. In addition to this, they are practically noiseless, and the objectionable cracking and hammering of the old open type of jet is largely eliminated by their use. The syphon jet does not appear,

however, to have the same range of adjustment that can be made with the plain jet, and in very severe weather cups require close watching which are equipped with this type of jet. In the case of tank jets, it is the practice of some engineers to draw the cold water at alternate jets from the bottom and from half depth of the tank, discharging at half depth from jets drawing from bottom, and at surface with jets drawing from half depth.

During the past winter, it was the writer's observation that considerable difficulty was experienced, due to the necessity of quickly putting into service additional risers, during very severe weather, on holders which were equipped entirely with the syphon type of jet. We finally resorted to the expedient of placing a live steam jet in conjunction with each syphon jet, and when the temperature dropped below zero, we turned on these additional jets, which obviated, to a large measure, the necessity of putting extra risers into commission.

The table on page 73, which is largely the result of the writer's experience, may be of interest. The boiler horsepower given, as required for 3,000,000 and 10,000,000 cu. ft. holders, is an average figure, there being times when the requirements are considerably above those given, and also considerably below at other times. The figures in the case of the 3,000,000 cu. ft. holder are based upon measurements with a steam flow meter, and in the case of the 10,000,000 cu. ft. holder, the actual evaporation being taken.

#### HEATING, HOT WATER.

Many of the instances, where hot water is used for the prevention of freezing in tanks and cups of gas holders, are in situations where local conditions make large volumes of hot water available, and in fact where the holder tank is used as a cooling medium, an example of such conditions being where hot water is available from fresh water condensers. In one instance, which the writer has in mind, the condenser discharge from large turbine units leads to a 5,000,000 cu. ft. holder tank, the inlet to condensers being taken from the bot-

DATA ON HOLDER HEATING.

Tank	Sec- tions	Capacity of holder (cu. ft.)	No. of jets		Type and size of jets			Average boiler hp.	Size of feeds	
			Tank	Cup	Tank	Size (ins.)	Cups		Hor. headers (ins.)	Risers (ins.)
Steel .....	3	500,000	1	1	Syphon	$\frac{3}{4}$	Syphon	—	1	$\frac{3}{4}$
Brick .....	2	1,000,000	—	1	—	—	Syphon	—	2	$\frac{3}{4}$
Steel .....	3	1,500,000	1	1	Syphon	$1\frac{1}{4}$	Syphon	—	2	$\frac{3}{4}$
Steel .....	4	3,000,000	2	1	Syphon	$1\frac{1}{4}$	Syphon	38.0	2	$\frac{3}{4}$
Steel .....	5	5,000,000	2	1	Syphon	$1\frac{1}{4}$	Syphon	—	2	$\frac{3}{4}$
Steel .....	5	10,000,000	2	2	Syphon	$1\frac{1}{4}$	Syphon	80.0	2	$\frac{3}{4}$

Spare risers are, of course, provided on the larger holders, but the necessity for their use has been so infrequent that the above figures can be said to fairly represent average conditions.

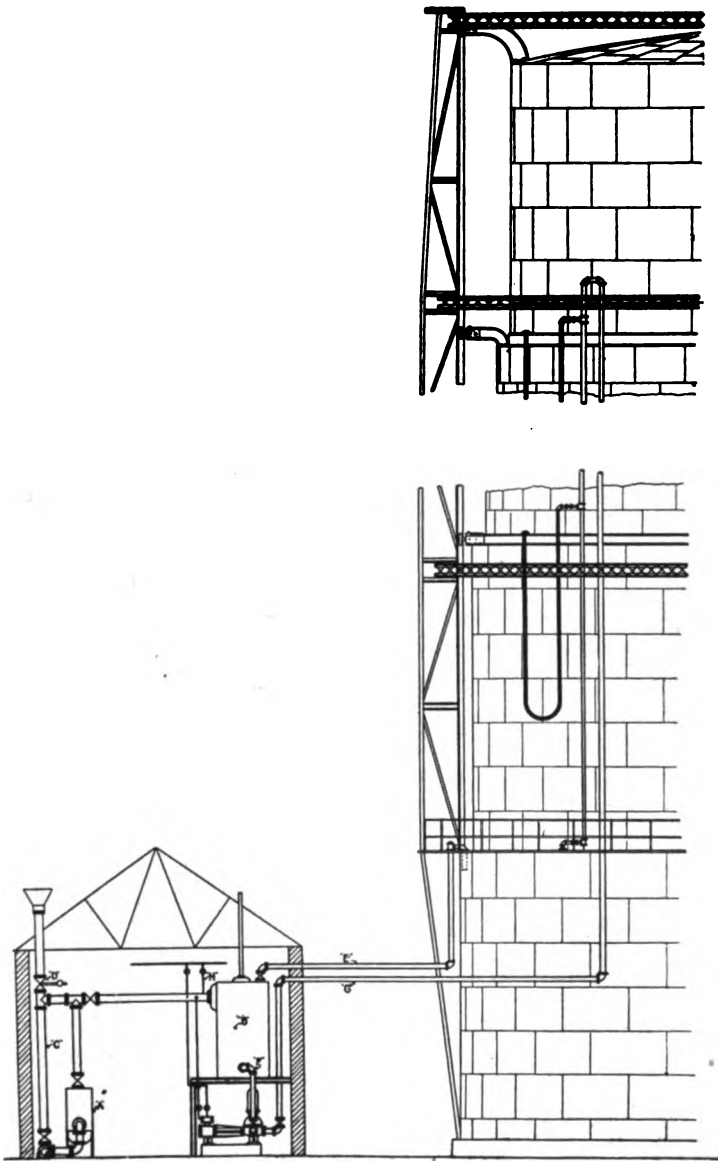


Fig. 26.—Heater installation for cup heating. Page 832.



tom of the tank, hot water being supplied in sufficient volume to preclude the necessity of using steam on the holder, except on upper cups in the very coldest weather. These conditions, however, will not be found frequently, and possibly the most common instance where hot water can be economically used, under ordinary operating conditions, is that of isolated steam driven distributing stations, where there is a large volume of excess exhaust steam. Such an installation is under the charge of the writer and has worked out satisfactorily so far. The installation is shown in Fig. 26 and is used in connection with two 5,000,000 cu. ft., 5 section, steel tank holders. The total engine capacity is about 1,100 horse-power.

The question of economy of this system depends entirely upon local conditions, such as the average amount of exhaust steam available, the distance the hot water must be moved, the type of holders, condition of cups and tanks, as to the possibility of good circulation, the character of holder water, (whether clean or otherwise). The size and type of apparatus, and size of piping used in the instalation follows:

- 1,000 horse-power Open Type Heater.
- 2 10 in. by 6 in. by 12 in. Single Acting Pumps.
- 8 in. Back Pressure Valve.
- 10 in. Exhaust Steam Inlet.
- 4 in. Cold Water Inlet.
- 4 in. Hot Water Discharge.

The system may be best explained by referring to Fig. 26.

Exhaust steam from the engines passes through the closed heater, "A," which was already in use at time of installing open heater. From here, the exhaust steam passes out and into the open heater, "B." Provision is made that, if necessary, the closed heater may be by-passed through line "C." A back pressure valve, "D," is inserted in the outboard exhaust, which is set to operate at about 3 lbs. back pressure. Open heater, "B" is supplied with cold water from line "E," which syphons its supply from holder tank, as shown. The cold water from the holder tank, having been heated by the ex-

haust steam in the heater, "B," is taken by the pumps through the pump suction line, "F," and discharged into the riser, "G."

It will be noted that the riser, "G," is taken up to a point above the highest cup, before any connections are made to the cup syphons. The cup connections are made to the return line, as shown in the sketch. The object of this double riser is to provide a uniform supply of water to all cups, as, if a single riser is used, the lower cups will rob the upper ones, unless the valves are throttled to such an extent that they are easily obstructed by small particles of foreign matter in the water. The second riser terminates in the tank syphon, which is used only in severe weather, as it has been found that the tank water receives sufficient heat to keep it from freezing from the overflow from the cups.

If, at any time, sufficient steam is not available to maintain the water issuing from the open heater at a temperature of 210 deg., high pressure steam may be admitted into the heater through line, "H." The cold water supply line, "E," should be equipped with an indicating thermometer, and the pump discharge, "G," should have a pressure gauge and recording thermometer. The pumps should have stroke counters and pump regulators. With the records of operation obtained by these means, reliable data may be had of the operation of the system.

From the available data, this system has shown a marked economy over the use of high pressure steam.

#### SKIMMERS.

It does not seem necessary to give any considerable space to the question of skimmers, as their operation is simple, whether of the permanent or temporary type, and well understood by all of us. It might be well, however, to point out the necessity of keeping the surface of the tank water as free from oil as possible, as many holders, especially of the older type, without dam sheets, are apt to throw oil on the outer surface of the tank and cup water, and the action of gas condensate upon paint of almost any description is extremely destructive and

one of the contributing factors to corrosion of cup and grip sheets at the water line.

#### SNOW CLEANING.

The organization of a force necessary to keep holders cleared of snow is a matter governed largely by local conditions. The practice in a number of the larger companies appears to be as follows:

The responsibility for having the requisite number of men on hand to keep the holder, or holders, at any given station, free from snow, is imposed upon foremen, generally attached to the street department. They have addresses of a sufficient number of men to do the work required of them. When the necessity arises, upon the starting of a snow storm, these several foremen get into touch with the superintendent or general foreman by telephone, and upon being instructed that shoveling will in all likelihood be necessary, they gather their men and proceed at once to the locality assigned to them, which, of course, is selected as being in the immediate neighborhood of their homes.

It is customary in some companies to pay snow shovelers an extra rate of wages for this work, and also to guarantee them a certain number of hours pay when once turned out. It is also well, where stations are located at remote points, to keep a supply of food on hand with facilities for properly preparing it, in the case of necessity, as men cannot work aloft during inclement weather without being properly fed.

It is also customary in many instances to keep a supply of rubber boots on hand for the use of snow shovelers, as it is also a difficult matter to get efficient work out of men who are cold and wet.

Care should be taken, when a snow gang is working aloft, to rope off or guard with red flags or lanterns, the danger zone in the street or yard into which snow is likely to fall.

It is also well to so regulate the handling of snow as to minimize damage to adjoining buildings, steam piping, hose,

etc., as this, after such a winter as we have just experienced, runs into a considerable item of expense.

Safety lines should be provided on all holders, whether equipped with guard rails or otherwise. These safety lines should be constantly in place during the winter season. On the majority of holders, provision will be found at the apex of the crown, either in the form of a perforated plate, or eye bolts, for the securing of safety lines for men on the crown.

#### DESIGN.

The following suggestions on the subject of design are contributed by Mr. Fred. H. Wagner:

##### *Holder.*

1. The metal in the shells and crown should be of sufficient thickness to permit of making all joints metal to metal.
2. Friction plates, or stiffener plates on the outside of the shells should be abandoned.
3. Cup and grip sheets should be of sufficient thickness to present a formidable body against the attacks of corrosion.
4. All carriage bases should be so arranged that water can drain off, and they should be readily accessible for cleaning.
5. No pockets for the lodgement of dirt should be permitted.

##### *Guide Frame.*

1. All members should be built up with the least number of individual pieces.
2. Lattice work should be abandoned whenever possible.
3. Cover plates should not be used on either standards or girders, and if used, the rivets should be spaced close.
4. All pockets for the lodgement of dirt should be avoided.
5. All parts should be readily accessible for cleaning and painting.

### *Steel Tank.*

1. All joints should be properly caulked metal to metal to prevent the admission of water.
2. All rivet heads should be tight to prevent weeping.
3. No pockets should be permitted between the standard support and tank shell.

Before closing, a word as to improvements in design of recent holders, observed by the writer, may be of interest.

In speaking of the different features of design, the reader is referred to Fig. 27, which shows a diagrammatic plan of the holder frame under discussion, having three sections and a capacity of 2,000,000 cu. ft.

### *Standard Supports.*

The standard supports are constructed in the usual manner, with the front and back chords and struts or stiffeners, formed of angles, the solid web plate projecting through the front chord.

The standard support is attached to the tank plates by means of angles, one leg of which is attached to the projection of the standard support web plate, and the other leg to the tank plates. These angles are of lengths somewhat shorter than the depth of tank plates, and are attached singly on alternate sides of the web plate, there being one angle to each course of tank plates. This eliminates the water and dust pockets found so objectionable in the older Z bar construction shown on Fig. 2, and also allows free access by painters to all surfaces exposed to the atmosphere.

### *Standards.*

The standards are formed of I beams of 24 in. in depth in the lower tiers and reducing to 20 in., 18 in., and 15 in. on the top tiers. The method of forming connections where the sizes of I beams reduce is to cut a triangular piece from web of the larger size beam and draw in the back flange of this beam until its cross-section corresponds as nearly as possible with that of the beam in the tier immediately above. The

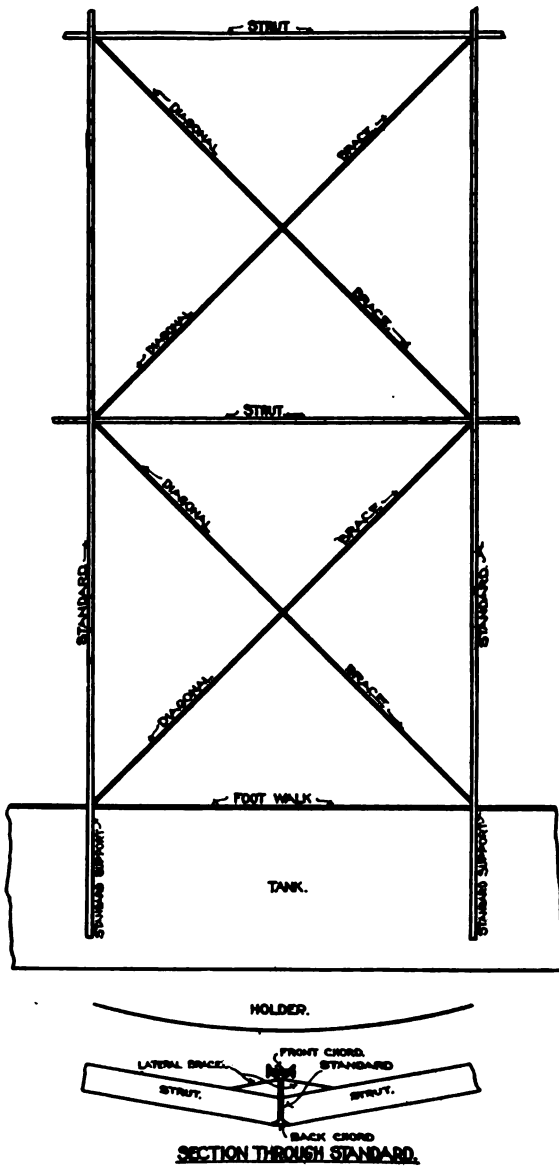


Fig. 27.—Gas holder frame work. Page 836.

ends of both beams are faced and when assembled, form a close joint, the weight of the standards above being borne directly by the standard in the tier below, no weight coming upon the riveted connection. This condition is assured by holes for connection plate in upper tier of standards being punched in the field, thus assuring their correct position after faced ends of I beam standards are butted.

The guide rails are formed of 12 in. I beams, riveted to the front flange of the I beams forming the standards, the rivets being counter sunk on the front face of guide rail to accommodate the guide rollers. The object of this wide I beam, in place of the usual guide rail, is to give the standards lateral stability, and thus obviate the necessity for the horizontal tie struts seen on older types of holders. It will be noticed by referring to the diagram that no horizontal tie struts are used in this construction.

#### *Struts.*

Struts are formed of pairs of 10 in. channels, spaced 6 in. back to back, with separators formed of 6 in. channels. At point of intersection of struts with standards, the structure is stayed laterally by means of triangular plates, one edge of which is secured to the strut channel flanges, and one edge being secured to the web of I beam forming standard by means of angles. This method of construction eliminates the complicated angle iron lateral braces seen in the older type of holder and very much simplifies the connection.

#### *Diagonal Braces.*

Diagonal braces are formed of eye bars, pin connected at their points of intersection with struts and standards. The connecting pins are equipped with cast steel eccentric rings. These rings are adjusted at the time of erection, so as to subject each of the diagonal members to an equal strain. After this adjustment has been made, a key plate is inserted in a key way in the pin and secured in position by means of a rivet through the web of the strut channel. The hole for this rivet

is punched in the field, after the adjustment is made at the time of assembling, thus assuring the adjustment of eccentric ring being properly made and its remaining in position afterward. The diagonal braces are not connected rigidly at their point of intersection in center of bays, but are held in position by means of a stirrup bolt.

#### *Horizontal Tie Struts.*

As has been noted above, the horizontal tie struts, with their objectionable latticing or batten plates, have been eliminated entirely by the use of 12 in. I beams on front chord of standards, in place of the usual narrow guide rail.

#### *Caulking.*

The edges of all connecting members, etc., are caulked to prevent the entrance of moisture.

#### *Carriages.*

The carriage and guide wheels of this holder do not show as marked improvement in design as some of the other members, as many improvements had already been made in carriage design in holders erected just prior to the one under discussion. The designs show the carriages to be compact with no inaccessible surfaces and raised well off the sheets supporting them, in order to insure proper draining. All wheels and rollers are supplied with grease cups.

#### *Hand Rails.*

All hand rails are formed of solid round bars, supports being formed of angles riveted to the stairways, grip channels, etc.

On another 1,250,000 cu. ft. 3 lift holder, of recent construction, we find the guide frame free from lattice work, cover plates, and all enclosed sections, water pockets, etc., horizontal tie struts being present in this construction, but with batten plates used in place of lattice bars.

The concrete guard wall is tied to the tank about 2 ft. 0 in. below top of wall by a 3 in. by 3 in. by 5/16 in. angle en-



circling the wall with rivets 4 in. C. to C., and outer leg punched every 6 in. to take hairpin wire for bonding into concrete. A groove 2 in. wide and 4 in. deep was left at top of wall and afterwards filled with 160 deg. pitch.

Guide wheels have double web, joining flange at outer edge with bearing surfaces faced. All bearings are equipped with grease cups.

All goose necks, where size warrants, have hand rails and ladders.

A gutter sheet of 7 in. by  $1\frac{1}{4}$  in. metal is provided extending above top curb of inner lift with drains to throw water clear of holder.

Guard rails are formed of 1 in. round steel and steel cable, no pipe or pipe fittings being used. Railing supports are formed of angles.

Cups are provided with adjustable overflows to allow of lowering water for scaling and painting.

Additional ladders and platforms are installed to insure safety of those having to reach the cup heating equipment.

All surfaces of guide frame, cups and grips, where concealed after assembling, were sand blasted and put together with coat of red lead. All other parts of guide frame, goose necks, and carriages were sandblasted in shop. The entire holder and tank were sandblasted after erection, followed immediately by a priming coat of red lead.

The writer is indebted to Messrs. Howard Bruce, Herbert W. Alrich, Henry L. Underhill, Jacob W. Stirzel, and A. H. Strecker, as well as the authors of the several publications and pamphlets referred to, for their assistance in compiling this article.

(Due to lateness of hour, abstract of paper was not read.)

THE ACTING CHAIRMAN: We will now enter on the discussion of Mr. Braine's paper. Is there any discussion?

MR. F. G. THORN (Philadelphia): The question of selecting structural materials is a very perplexing one to the engineer

of to-day. A few years ago, it was thought a happy conclusion had been reached in the application of steel and concrete, and the combination of the two; but, as has already been shown in the paper just presented to you, we have not yet passed the experimental stage in solving this problem; steps have been taken in the right direction, but, owing to the desire for speed and low cost of production, the mark has been overreached.

There seems to be no doubt of the superiority of wrought plates of a few decades ago over the present day manufacture of commercial steel, for resistance to corrosion.

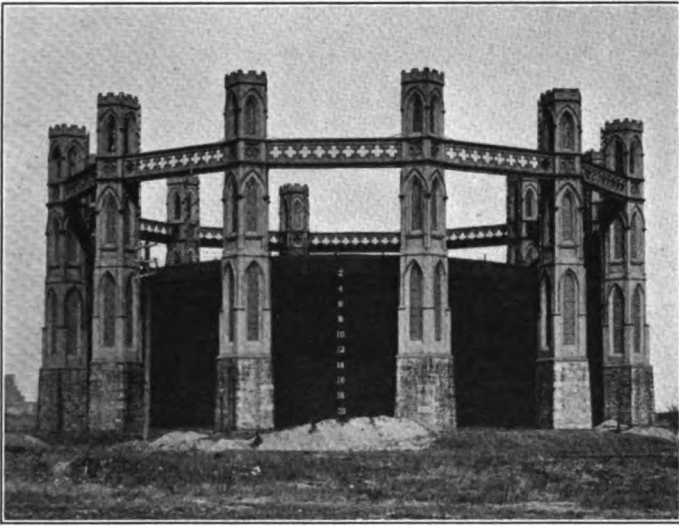


Fig. 1.—This holder was completed in 1854; the two upper sections were in use until 1898.

Fig. 1 is a photo of a holder built in 1854. This holder gave way at the cup of the middle lift in 1870, in all probability due to design, as it still never worked satisfactorily after replacing this cup 10 years later. We understand, however, that the two upper sections were in constant operation from the time it was built until 1898, when the entire structure was rebuilt, and at which time the metal was still in very good condition.

Some of the manufacturers of steel plates are now trying to put out a product equal to that of earlier years, but it remains to be seen whether the old conditions can be reproduced by new methods. Steel plates are now on the market under different trade names, which will analyze from 98.75 per cent. to 99.92 per cent. pure iron, the higher grades of which, according to the electrolytic theory, should give very good results; but this fact must be borne in mind, that the purer the

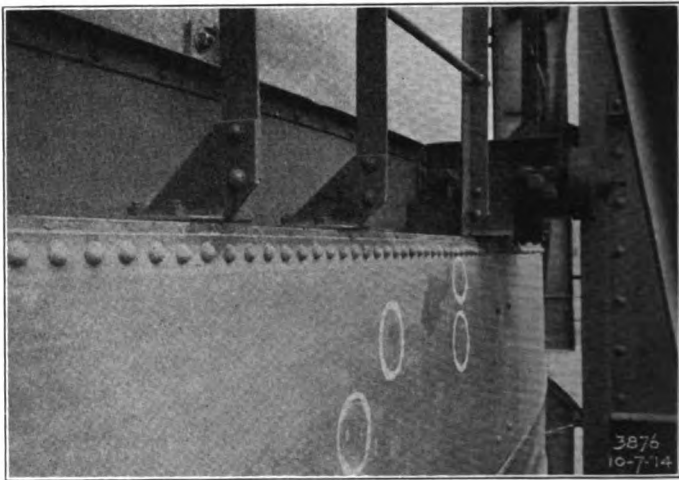


Fig. 2.—Showing corrosion spots on commercial steel plate used to replace 99.8 per cent. pure iron plate (condemned). Note the railing supports of open hearth steel. Holder built in 1912.

iron, the stronger its affinity for oxygen, with the result that after specifying and using a grade of metal to resist electrolysis, we will be confronted with a very heavy rust, a sample of which analyzed ferrous oxide and ferric oxide. It is therefore necessary, in order to protect the metal of whatever grade is used, to select a good grade of paint, and see that the metal is thoroughly covered and kept covered. The adoption of the inspection system and the printed forms of reports, as out-

lined in Mr. Braine's paper, would doubtless go a long way toward checking corrosion before any damage could be done.

Mr. Braine mentioned a holder constructed of iron analyzing 99.8 per cent. pure iron, in which a few sheets of steel were placed. On inspection of this holder, in less than two years after it was completed, it was found that one of the steel plates had started to corrode in several places (Fig. 2), but no spots could be found on any of the other sheets. The entire holder had been sandblasted after erection and immediately covered

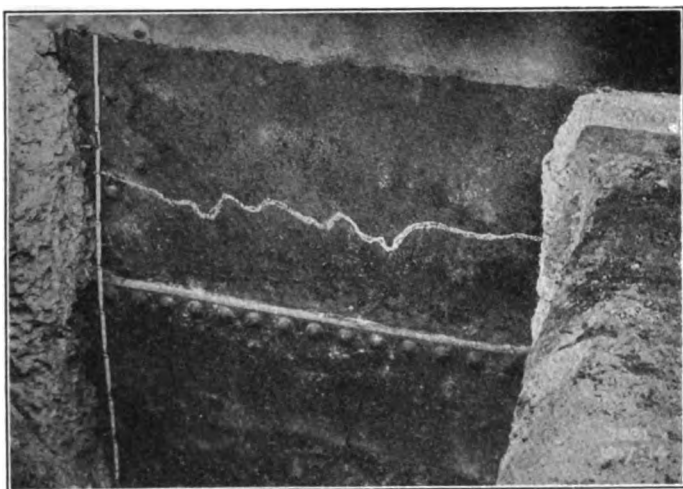


Fig. 3.—Holder tank plate of open hearth steel with portion of concrete wall removed. Holder built in 1902.

with priming coat of red lead before nightfall on each day's work. You will note in the photograph, the bases of the cup gallery railings are also corroded. Numerous spots of this kind were found on the open hearth steel used for other parts of the holder.

Referring to the comments on corrosion of metal backed up with concrete, it is very evident from the cuts shown that it is impossible to keep the steel and concrete in intimate contact as already stated. Fig. 3 shows a similar condition found on

a holder tank built in 1902 of open hearth steel. Although the conditions found on this holder are very similar to those already described, they are not alarming. The pitting of the plate seems to be practically all above the chalk line, *i. e.*, from 18 in. to 20 in. from the top of the concrete; the irregularities shown below this line are principally cement out of the concrete, which adhered to the plate. The conclusions to be drawn from the exhibits are that the line where the pitting stops is very close to a line where a nearly uniform temperature throughout

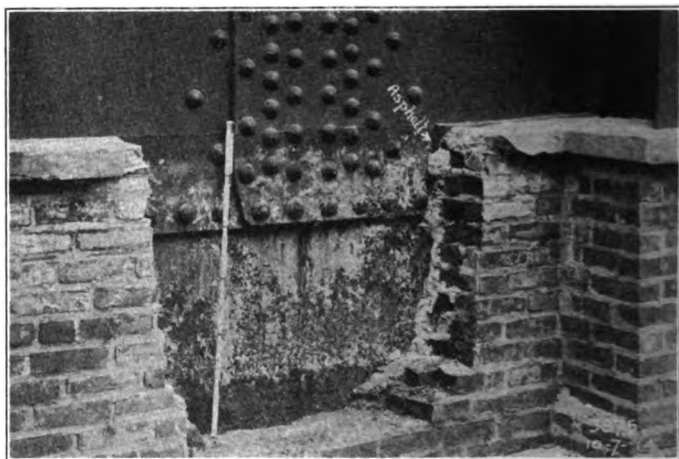


Fig. 4.—Holder tank plate of open hearth steel with portion of brick and concrete wall removed. Holder built in 1908.

the year will be found. The movement of the plates above the line, due to expansion and contraction, has torn the plate away from the concrete, thereby allowing water to enter from the top, and the chemical action already described to take place, while below the line, no movement having taken place, we still find the adhesion of the two substances and necessarily little or no corrosion. On two other holders built in 1908, also of open hearth steel, the tanks were constructed with brick protecting walls backed up with concrete grouting to within 3 or 4 in. of the top, and then filled with asphalt.

Fig. 4 shows a portion of this wall removed from one of the holders. The asphalt has very effectively protected the metal as far as it reached, the paint back of it being in as good condition as when put in; the brick walls, however, have absorbed moisture, increasing in amount below the protection given by the overhang of the coping, the corrosion increasing with the moisture. The lower two courses of brick were cut out while the photographer adjusted his camera and the moisture back of these bricks shows very clearly on the photo.

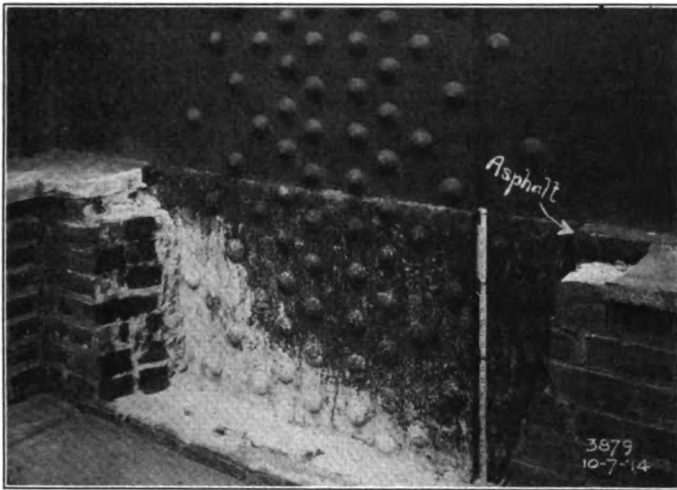


Fig. 5.—Holder tank plates of open hearth steel with portion of brick and concrete wall removed. No corrosion where concrete was in close contact. Holder built in 1908.

Fig. 5 shows a portion of the wall removed from the other holder. In this case the asphalt had not laid up quite so close to the tank, but a portion of the cement grout was particularly close and compact, as can be noted on the left. The light color on the tank is the original priming coat of red lead.

Since examining the walls sealed with asphalt, it has been decided to inject between the tanks and the retaining walls a heavy 700-degree oil distilled from water gas tar and seal the

top with 160-degree pitch. The use of pitch in place of asphalt has been tried, and it was found instead of forming a hard substance that would separate from the steel plate in cold weather, it lays very close to both the metal and concrete, winter and summer, and in the coldest weather is soft enough to take the imprint of a finger nail.

Experience along another line, which demonstrates the superiority of tar products over concrete for preventing corrosion, will doubtless be of interest to users of gas holders. It was necessary to increase the pressure of several holders equivalent to about 2 in. of water, and it was decided to distribute the additional weight over as much of the crown as possible. A circular curb angle was bolted far enough back from the edge to miss the guide roller brackets, and the enclosed circle weighted.

In the first case (in 1905) the crown was sandblasted and coated with red lead, after which a reinforced concrete covering,  $1\frac{1}{2}$  in. thick, was put on, care being taken to thoroughly swab the crown with a mixture of cement and water just before the concrete was laid.

During the following year another holder was treated the same way; the third was sandblasted, red leaded, and covered with five thicknesses of roofing felt, in the usual manner employed for pitch roofs, each layer laid in a swabbed coat of hot coal gas tar, and over this was laid a sheet of mastic asphalt ironed into a compact mass; the fourth and fifth holders were treated in the same manner, except the asphalt was put on in small blocks about 6 in. square and  $1\frac{1}{4}$  in. thick, laid in hot asphalt.

In about five years it was found that the crown of the first holder was so badly corroded that the concrete was taken off. The second holder was examined in several places and found in good condition; after a lapse of six months, it was again examined, and it was found very active corrosion was taking place, and the concrete was immediately removed. The other three crowns have been examined systematically every six months, and are still in good shape.

Mention is made in Mr. Braine's paper of trouble arising from outside vertical legs. Very serious trouble of a different character was experienced on a holder built in 1902, the vertical legs of which were built of two 6-in., 8-lb. channels, one inside and the other outside of the holder, with the flanges of the channels placed toward the shell and attached thereto by  $2\frac{1}{4}$ -in. angles  $\frac{1}{4}$  in. thick. After the holder had been in service eight or nine years, it was found that the outer channels of the third lift were rubbing on the grips of the outer lift when cupping and uncupping, due to an outward bowing of the vertical legs. As this bowing outward increased, the friction caused a downward thrust on the vertical legs of the outer lift, a strain they were never intended to carry, which resulted in buckling the outer section legs. It can be imagined how this holder labored from the condition of the outer section channels, as they were not only bent in both directions radially, but the web of some were curved, and the flanges of two of the channels were cracked, also the  $\frac{1}{2}$ -in. connecting bolts were very badly cut. It was not desirable to purge this holder to make repairs, and the work as described was done with gas in the holder.

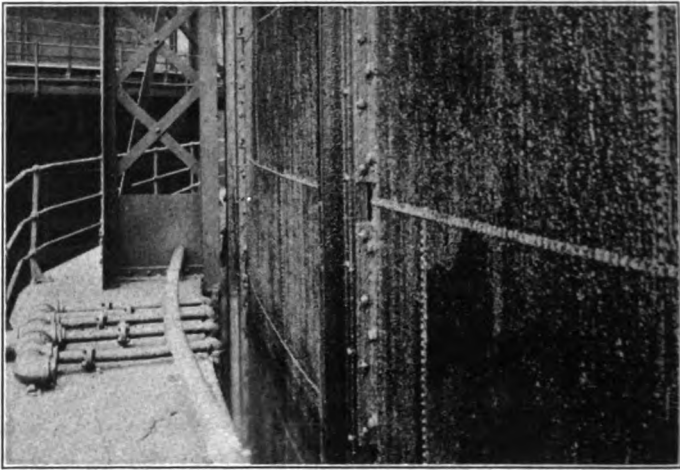
For the outer section, new channels of the same size as the old, and 4-in.,  $9\frac{1}{2}$ -lb. I-beams were purchased and assembled in the shop, the I-beam forming a fin on the back of the channel (Fig. 6). The old channels were removed one at a time, and replaced as shown, after reaming out the connecting bolt holes, which were badly out of shape, to fit a larger bolt,  $\frac{5}{8}$  in. in diameter.

On the third lift, the outer legs were removed one at a time, and while one set of men replaced the connecting angles, for which  $2\frac{1}{2}$  by  $2\frac{5}{16}$ -in. angles were used, another set of men straightened the old channels, and they were replaced with heavier bolts, the same as the lower section.

Although the general use of roofing cement, putty and other fillers that will become hard and crack, is not advisable, there are times and places where it is necessary to use a filler; the



following have been found satisfactory and non-corrosive. Where corrosion has taken place under outside stiffeners to the extent of causing small leaks or in case of leaks in shell plate joints that cannot be caulked, mix with one part linseed oil and three parts glycerine, sufficient litharge to form a paste (this should be mixed in small quantities on a tin plate, sheet of glass or other non-absorbing substance), remove all rust or dirt and use the same as putty. If openings are large, absorbent cotton, dipped in a more liquid mixture of the above can



**Fig. 6.—Outside vertical leg of holder reinforced to remove buckling.**

be packed in. This mixture will stand the action of gas and remain elastic.

For inaccessible places not in contact with gas, there is a material known as mirror stone, which when mixed with a little plaster of paris and whiting, will make an elastic cement.

Last year, repairs were made to a holder, without purging, that are worthy of mention. The bottom section of a relief holder, 140 ft. in diameter, became badly buckled from landing on an accumulation of breeze and heavy tar in the bottom of the pit. The buckling extended from the sixth sheet from the

bottom curb angle; the force was applied by block and fall; the fourth sheet from the bottom where an inner leg occurred; this leg was broken in half and the steel caved in 3 ft. from its original position. The bottom curb was twisted in every direction for a distance of 12 ft. either side of the inner leg, in one place 12 in. inside the circle, and at another 10 in. outside.

The method adopted to straighten out these buckles was simply a matter of push and pull. A series of holes were cut on either side of the inner leg at intervals of 30 in.; at each set of holes a wire cable was fished through, each end of which

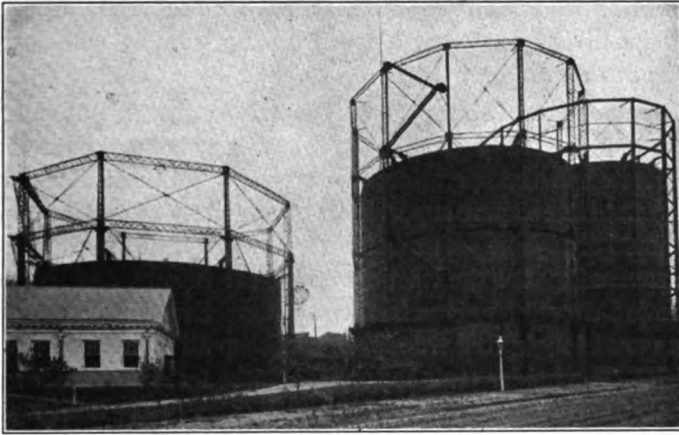


Fig. 7.—Three types of holder guide frames, 1870, 1902 and 1912-13.

was attached to a screw hook bolt that passed through a yoke placed back of the I-beam roller guide. By screwing up these bolts and putting pressure at necessary points to get the proper opposing force, the shell was forced back toward its original shape; pressure was also applied to the high points of the bottom curb by a series of levers tied to the holder curb; these levers were constructed, like a bell crank, of railroad iron with heavy timber between the resistance end of lever and the bottom curb angle; the force was applied by block and fall, all forces were applied as near simultaneously as possible, with

the result that the steel was freed of all buckles measuring over a few inches. A 9-in. ship channel was attached on the outside to reinforce the broken leg, using hook and tap bolts as conditions dictated.

Following the text of the paper under the heading "Faults in Design," Fig. 7 is a view of three holders, built at different periods, and which show the evolution from the old cast iron column guide frame, which was afterward extended to accommodate another lift, to the solid member guide frame shown on the right. This last design has eliminated practically all the objectionable features mentioned under this heading.

"Faults in Construction" bear such close relationship to "Faults in Design," that a word on this subject will not be amiss at this time.

**Foundations:** This part of the work, always put out of sight and generally done before any very active interest is manifested in the operation, has received the most abuse and often the least expert supervision of any class of work known. It should always be remembered that the parts of the work that are covered up are the least accessible for repairs, and the best attention should be given in the making. See that all foundations are brought to a true level, and keep all work level to the finish. The holder tank bottom should be tested before lowering on the foundation. Establish the center of the holder permanently at the start in such a way as to be able to use it until the work is finished.

Inspect all materials as soon as received; material condemned when needed for erection, causes unnecessary delay.

Particular care should be taken to check up the radius of all sections and to see that each is of proper radius and the same radius throughout. See that bottom curb and cup channels rest properly on landing blocks.

Look out for buckles; members that are not cut and punched true enough to go into place without excessive strain, will sooner or later cause a buckle, which, if pulled out, cause other undue strains with a like result.

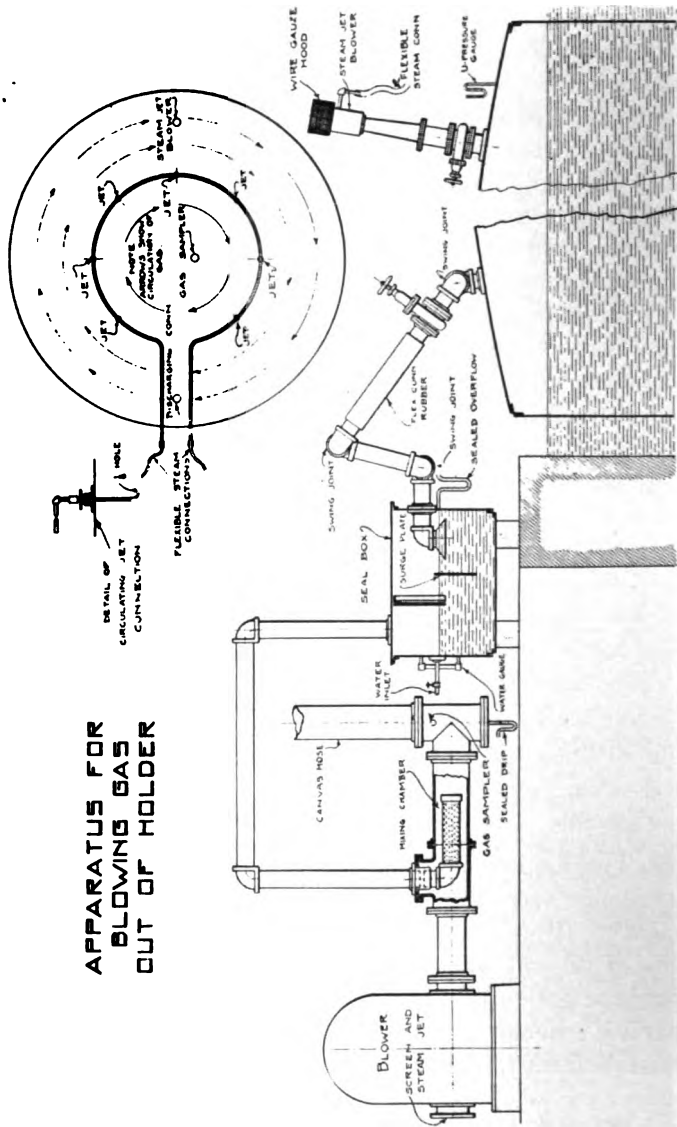
Cups and grips should receive special attention and checking for clearances, and the cups tested for leaks. Inner legs must be vertical and straight, and inside rollers perfectly adjusted and thoroughly secured in place. Guide columns should be checked with an engineer's transit both radially and tangentially. Outside guide rollers must be in perfect adjustment and roller bracket braces taut. Lubricating devices for outside rollers must be accessible and free from fouling other parts. Valves should be tested before putting in place and connecting pipes thoroughly tested before covering. Examine all castings for skimmers, overflows, bonnets, manholes, etc., and see that they are all free from flaws and defects, and that finished surfaces are true; pay particular attention to plugs, caps, bolts, etc., that enter castings, to see that they are in place and tight.

When assembling parts to rivet together, all holes should line when two drift pins are inserted; do not allow excessive use of drifts. Burrs on punched holes should be ground off before leaving shop. Examine all rivets and bolts; bolts in inaccessible places should have lock nuts. Examine inside all cups and under cup channels and bottom curb for stray tools, rivets, bolts, etc., and remove all loose lumber from inside tank before water is put in.

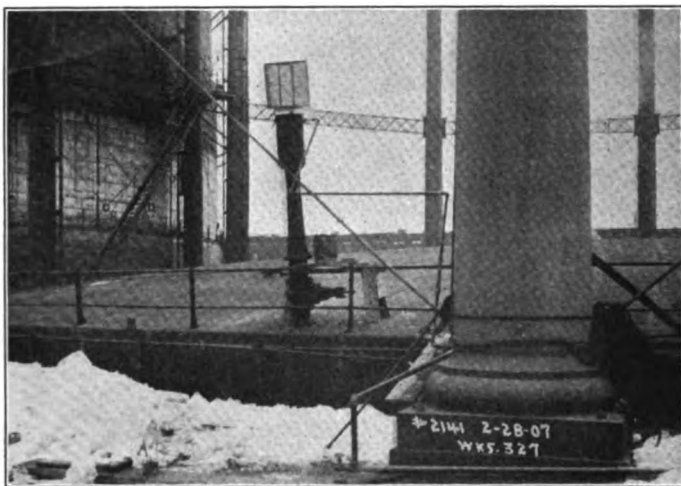
With all these suggestions, there is one "don't." Don't be alarmed when you find the inspector is the most unpopular man on the job.

Under purging holders, Mr. Braine says, "Remove as much oil as possible from the surface of tank water by means of skimmers." It is important to bear in mind that a small quantity of oil and whatever emulsion is there, also carrying oil, cannot be gotten rid of by use of skimmers. The presence of this oil is a factor that has to be reckoned with in purging, and several steam jets should be placed in the crown, not only to circulate the air but to evaporate as much of this oil as possible. It is readily seen that with these conditions, calculations by volume are not reliable to establish the limits of explosive

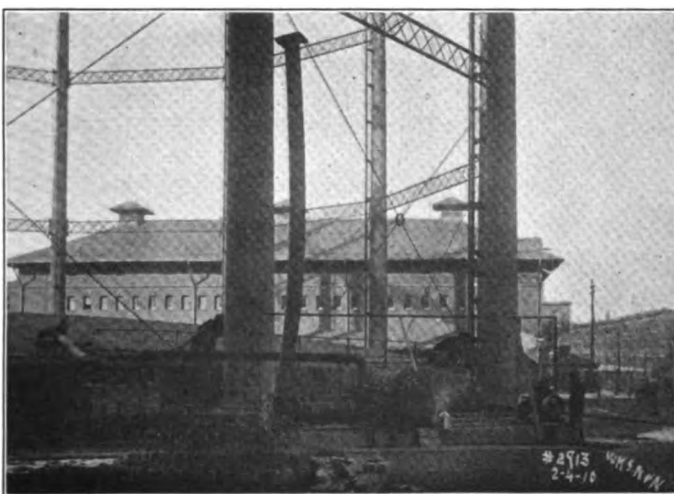
# APPARATUS FOR BLOWING GAS OUT OF HOLDER



**Fig. 8.—Apparatus for purging holders.**



**Fig. 9.**—Installation of steam jet blowers for purging holder.  
Capacity 60,000 cu. ft. per hour.



**Fig. 10.**—System for discharging gas, before explosive mixture is reached.

mixture, and the safest method is to have a chemist on the ground to make actual tests of the mixture at intervals of as short duration as possible.

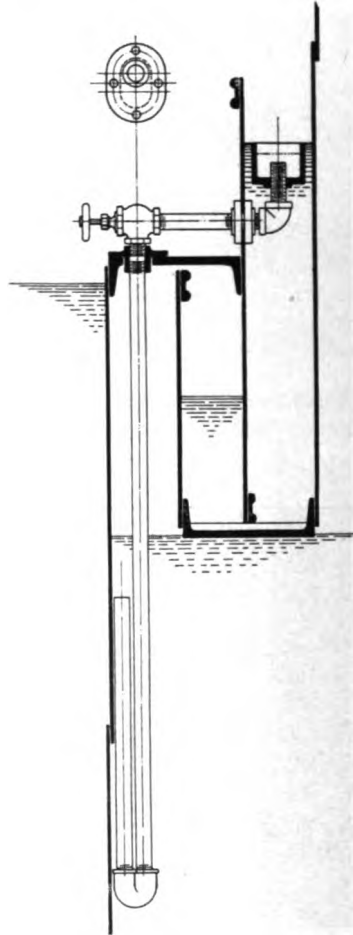


Fig. 11.—Suggested design for cup skimmer.

A method of purging used by some engineers has certain safety features which warrant its consideration.

This method is best described by reference to Fig. 8 and a description of the apparatus needed is as follows:

A steam jet blower of suitable size, equipped with a gate valve the full size of the outlet end, is attached to the crown of the holder; the air inlet end of the blower is covered with a

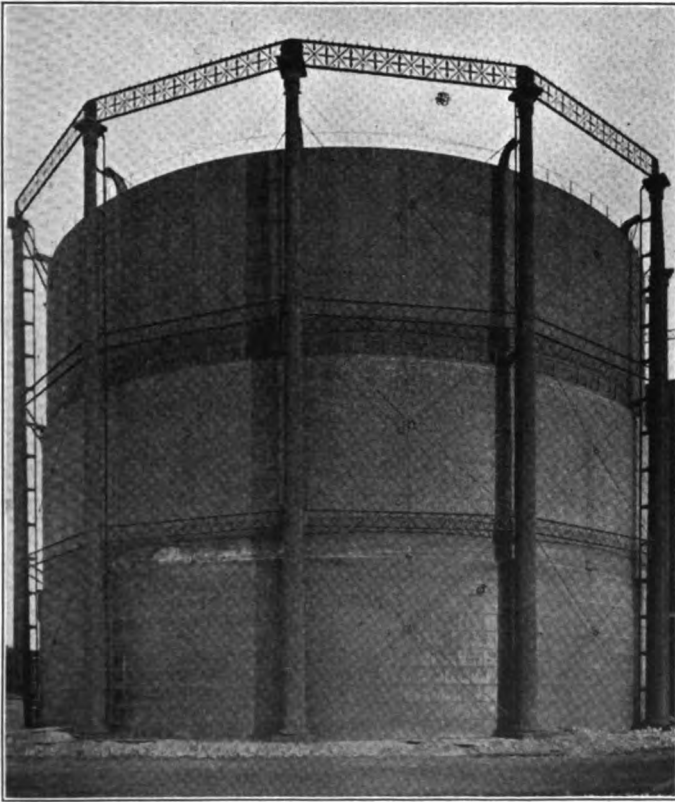


Fig. 12.—Holder showing paint stained with emulsion.

double wire gauze hood, of copper wire 34 meshes to the inch.

Two semi-circular pieces of pipe are placed on the crown about midway between the curb and the center; from these pipes several connections are made with flange and bushing





Fig. 13.—Valve and boiler house in 1898.

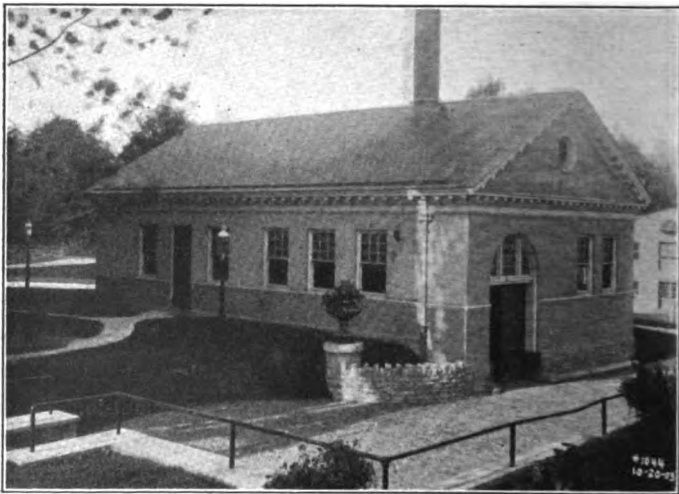


Fig. 14.—View of valve and boiler house in 1903, same location as Fig. 10.

through the crown of the holder, and each connection is equipped with a  $\frac{1}{8}$ -in. nipple jet. These jets are so set as to create a circulation, to more thoroughly mix the gas and air, and are afterward used to evaporate any oil remaining in the holder.

Flexible steam connections are made to the jet blower and

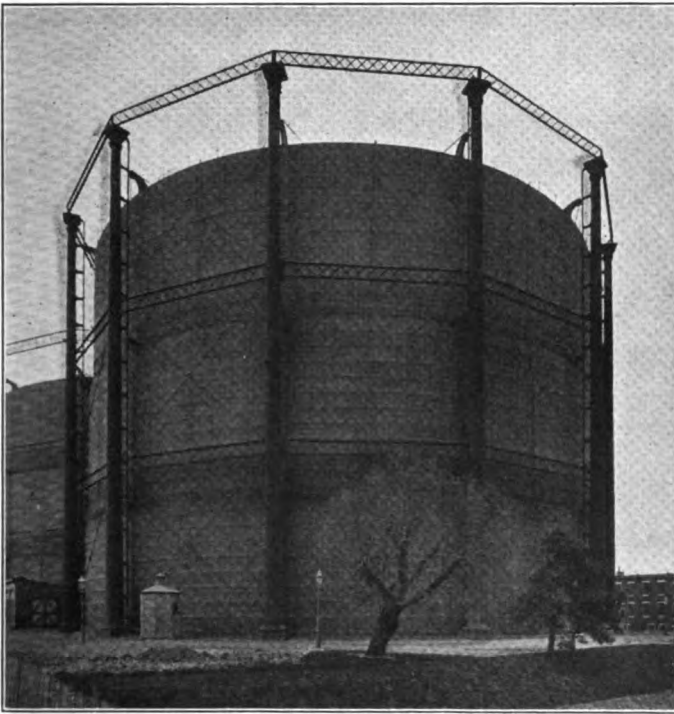


Fig. 15.—Holder station as seen from a railroad in 1898.

the circulating jets in such a manner as to supply steam to them during inflation to the entire height of the holder.

Diametrically opposite to the steam jet blower, a connection is made for discharging the gas to the seal box. This connection should have a gate valve as close to the crown as possible, and swing joints, to allow the holder to be slightly raised (not

over 3 ft.). A seal box separated into two compartments by a dip sheet and equipped with a surge plate, water gauge, water inlet and seal overflow, so arranged as to carry 1-in. water seal, will prevent any possible explosion being carried back through the outlet pipe.

A blower with a mixing chamber on the outlet is connected to a canvas stack of sufficient height to discharge the final non-explosive mixture above the heads of the operators. The inlet of the blower is covered with a wire gauze and supplied with

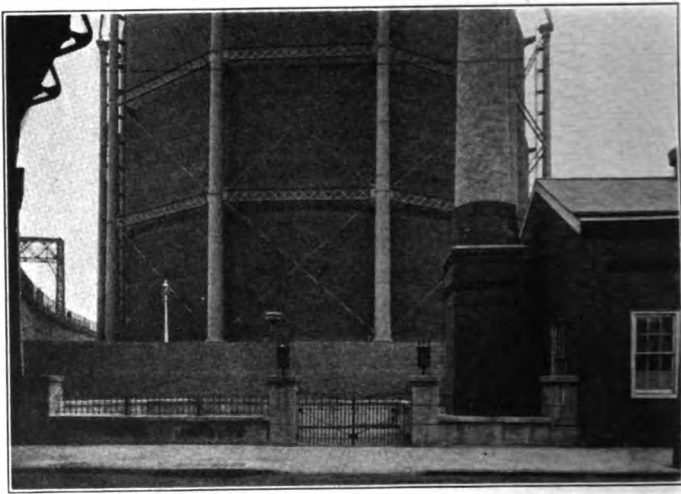


Fig. 16.—The same holder station in 1914 as shown in Fig. 15.

a steam jet to saturate the air as a precaution against friction sparks. The mixing chamber is made up of a tee and straight length of pipe a size larger than the outlet of the blower; into this tee and length of pipe, the end of the outlet from the seal box is connected; this end is capped and sufficient small holes are bored in the circumference of the pipe to equal its area.

On the crown of the holder near the center a flange and stuffing box is placed through which a small pipe, with valve, is inserted for taking samples of the gas in the crown. This

pipe should be adjusted to get each sample from about mid-way between the crown and the water, in order to get an average of the mixture.

On the crown of the holder there should also be a U-pressure gauge for noting the pressure in the holder.

The method of procedure, after having removed as much oil as possible from the surface of the water, is to land the

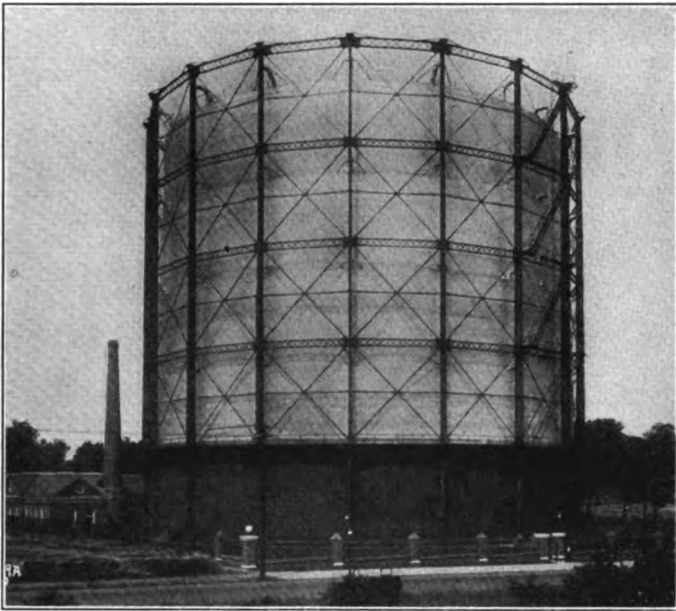


Fig. 17.—Holder station in residential district.

holder, close all connection valves and seal all connections with water.

Turn the steam on the circulating jet system and start up the blower. By the time the blower has acquired its speed, the jets will have the gas inside the holder in circulation; the steam jet blower can then be turned on and the outlet valve cracked, and so regulated as to give a mixture at the base of the canvas stack of about 1 gas to 60 air. Samples taken at

this point and exploded in a contraction apparatus will soon establish the steam supply and the opening of the discharge valve. They should be so operated as to get a very slow inflation of the holder to avoid the necessity of shutting down the jet blower on account of the limited range of the swing joints on the discharge pipe.

This operation can be continued until the tests of samples taken from under the crown show a close approach to an

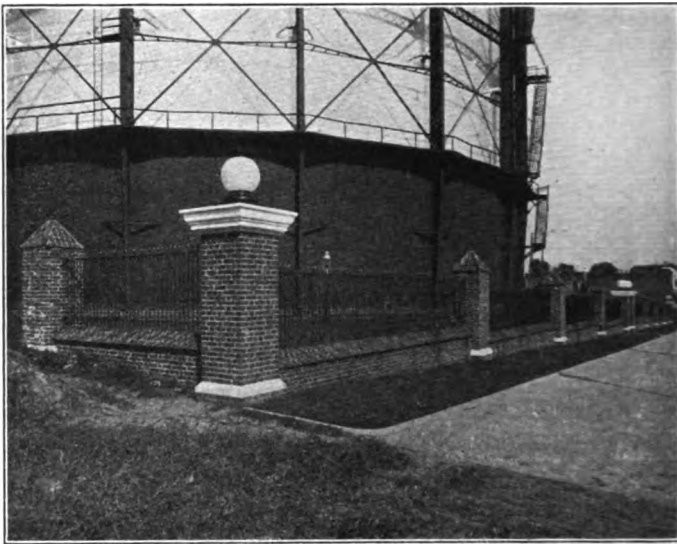


Fig. 18.—A nearer view of holder station shown in Fig. 17.

explosive mixture, when the discharge valve should be closed and the discharge pipe disconnected and moved clear of the crown, after which the jet blower should be turned on full and holder inflated as rapidly as possible, until the entire contents is considerably past the explosive mixture. The contents of the holder can then be safely discharged through both the discharge valve and the jet blower direct to the atmosphere. After landing again, the discharge connection can be coupled

up, and the circulating jets used to steam out any oil remaining and discharged through the canvas stack.

The manhole plates can then be removed and any emulsion remaining on the water should be broken up with a fire hose and skimmed off.

Special care should be taken to make the time the explosive mixture is in the holder as short as possible, and under no consideration should an explosive mixture be left in the tank after the hour of lighting lamps. Care should also be taken to keep the holder sufficiently inflated at all times, to prevent the possible changes of temperature from contracting the gas, thereby landing the inner lift and causing a vacuum, in which case there would be danger of collapsing the crown.

Figs. 9 and 10 show the apparatus, described above, set up ready for operation.

After driving off all the gas and the holder is landed, if the balance of oil and emulsion remaining are not thoroughly removed, it will float on the water, and deposit on the mound or bottom of the pit when the water is pumped out, where it will continue to evaporate to such an extent that it will be dangerous for workmen to enter the holder.

It is the exception, rather than the rule, to find a man in charge of a piece of machinery who is not proud of the appearance of his machine, but how often do we see a holder or a holder station that is not kept in spick and span order. The first cry is "we can't keep the paint in good shape on account of the oil;" get rid of the oil; this can be done to such an extent that so little is left inside, that with proper regulation of the water level, it can generally be kept inside; where this is impossible, the use of a cup skimmer, such as has been suggested to the writer recently, should do the work, and which can be put on a holder while in commission, see Fig. 11.

The general design of an inside cup overflow has the disadvantages of being inaccessible for repairs when holder is in operation, and also, under certain conditions, of being the

means of discharging oil from the inside of the holder into the cup during the uncupping process, both of which have been overcome in this sketch. The U-tube inside the lift can readily be fastened to the side by the use of a hook bolt, and details for clearances and seal worked out for individual cases.

An emulsion of oil will often form on the surface of the water inside of the holder, which cannot be removed by skimmers as readily as the clear oil. When this material gets on the outside, it should be removed with a skimmer built of a wire loop narrow enough to insert in the cup, and covered with wire netting. If not removed, a thin dirty white layer will be deposited on the paint, as seen in Fig. 12, in which case it can be removed by wiping off with kerosene.

With the suggestions that have been made, is it not possible that holders and holder stations can be kept presentable, and not a blot on the landscape to depreciate the value of surrounding properties?

Let us look at Fig. 13, a valve and boiler house about 1898, and then at Fig. 14, the same location in 1903. Again at Fig. 15, a holder station as viewed from the railroad in 1898, where some 200 trains passed each way every day, and Fig. 16, the same holder station to-day. And Fig. 17, a holder station built in 1910 under protest from surrounding property owners, who claimed it was a residential district and should not be disfigured by an unsightly holder. At the time it was erected, there were open fields for several blocks in every direction; to-day tenant houses and apartments of very substantial character are closing in around it rapidly, in fact, on one side adjacent property has been entirely built up, while on the other side, unimproved land is steadily advancing in price, as evidenced by record of sales. Fig. 18 is a nearer view taken more recently.

MR. W. H. GARTLEY (Philadelphia): I want to give you some idea of the complaint that was made by people in that location. The Ward Improvement Society, and the Superintendent of the Schools, objected to placing the holder there,

because they were going to build, and did build, a new school five blocks away. He complained that the noise from the working of that holder would so disturb the minds of the children that they would not be able to conduct their studies properly. The Pyramids of Egypt had nothing on that holder for quiet operation. (Laughter.)

THE ACTING CHAIRMAN: Is there any further discussion?

MR. GARTLEY: I might add to that, because it is quite worth while. You know these complaints about the location of holders. The result of that holder being located there, or the condition in which it was kept, instead of depreciating property, very much improved the property in that location as compared with what had formerly existed there. Formerly there were several rows of two-story houses. To-day there are several expensive apartment houses going right up within one block of that holder.

MR. E. C. UHLIG (Brooklyn): (Written discussion communicated.) The preservation of structural iron and steel is one of the most important problems of our age. Much has been written on this subject, and many investigators are engaged in research tending to throw light on the causes of corrosion and its prevention. The many theories advanced to explain corrosion have their ardent advocates, but it cannot be said that we are able as yet to write definite specifications for structural metal. It seems to be general experience that the iron of former periods is more resistant to corrosive influences than the present day metal. This may be ascribed to two reasons, namely, the composition of the metal, and the corrosive influences surrounding it. The former is probably the true one, as ancient iron in use at the present day is exposed to the same conditions of corrosion as the modern iron, and writers say it resists better.

If the virtue of the ancient iron lies in its freedom from impurities, then the more our metal approaches pure iron, the more resistant should it be to corrosion. If the ancient iron is superior on account of its freedom from molecular strains due



to its slower and more thorough methods of manufacture, then the structural metal we use will have to be produced with more care to eliminate these strains as far as possible.

The slow and laborious methods of former periods are undoubtedly responsible for both the purity and freedom from molecular strain, but it is useless to expect even an approximate return to ancient conditions. On the other hand, the case of the Newburyport chain bridge might be cited. This bridge has withstood corrosion for nearly a century, and the iron is remarkable for its heterogeneous composition having large areas of pure iron mixed up with areas of slag and very high carbon. This case is one where the ancient iron was not pure.

The reference to iron containing copper is interesting and possibly the solution of the problem of corrosion might lie in this direction. At any rate, the corrosion of iron and steel as influenced by the composition of the metal, is a problem which directly concerns the manufacturers, and it is to be hoped that they will solve it.

In regard to the protective coverings such as compounds and paints, it is quite impossible to specify composition, and the real test, as Mr. Braine points out, is actual service, guided by knowledge of the manufacturer's reliability. However, an analysis or else some test is quite desirable. The test of compound on page 788 is a case in point. The exposure of a coated plate to the action of an acid, furnishes an idea as to the protective qualities of the compound.

Our analyses of red holder paints have shown them to be composed mainly of iron sesquioxide and calcium sulphate, the last named being added to brighten the color and thus produce the vermilion shade desired. The oil in the paints has been mainly linseed oil, containing sometimes mineral oil and turpentine. Some paints had also organic dyes present. The use of these dyes is objectionable, as a rule, because they are liable to wash off in the rain and also fade. Some of them may be free from these objections, as I have heard that aniline dyes

have been employed in paints used for outside railroad signals apparently with satisfaction.

It might be well to state here that the theory of the use of linseed oil as a vehicle is that it becomes oxidized on exposure to the air, producing a hard film which holds the pigment. This oxidization is influenced by the moisture of the atmosphere, and it must be borne in mind that paints should be mixed to suit the conditions of the season of the year in which they are used. This is a question for the paint maker, and he should mix his paints with such conditions in view. The presence of mineral oil in a paint is objectionable, and should be considered an adulteration.

The purging of a holder, while usually regarded as a simple matter, presents two sources of danger, one the presence of an explosive mixture, and the other the nuisance of the odor. Frequent periodic testing should be employed. In the test mentioned by Mr. Braine on page 806 where air was applied with a steam injector, a very close watch was kept on the progress of the purging, both by analysis and explosion tests. It was found that even when the usual explosive limits of mixtures of gas had been long passed, the air in the holder was still explosive. This, of course, was due to the oil vapors produced by the heat of the steam, and the holder was not considered safe until the explosion test gave negative results, which happened when the percentage of air reached 96. This was very interesting, and the tests employed furnished a simple means of making the purging a safe operation.

MR. F. J. DOWN (New York): (Written discussion communicated.) From the reading of Mr. Braine's paper, one is impressed with its thoroughness and completeness. He has so fully exhausted his subject as to leave but little to be said by way of criticism. If one were to comment at all, it would be simply to say that too little attention has been given to the matter of cup cleaning. This duty, particularly in these days of forced draft with flake ash and cinders falling about our holders from our neighbors' boiler stacks, has become one of

considerable importance. Cases can be cited where, in a short period of time, the accumulation in the cups of holders from this source has been so great as to cause the seals to "blow" and become a menace to the neighborhood.

Something should have been said regarding methods of lubricating the guide rollers. The knowledge obtained from the use of grease cups and anti-friction rollers would, I am sure, be of value to many of us. Compression cups have been used, and, I have been told, have proven very satisfactory.

No mention is made of the use of cup guards. In former years, our chief engineer, Mr. Bradley, invariably provided for them in the construction of his holders. For some reason, not apparent, the practice has fallen into disuse. Their utility, in my opinion, cannot rightfully be doubted. They protect the cups from such injuries as result from the accumulation of stones and other missiles thrown by the small boy of the neighborhood. About five years ago a piece of bar iron thrown into the cup of a holder, worked itself under the grip sheet and buckled it so much out of shape as to prevent the cupping of the holder and necessitated its being put out of commission for three weeks to repair the damage. Were the holder provided with a cup guard, this would have been avoided.

As a protection against the freezing of the water of the cup in cold weather, the cup guard performs an important function in retarding the diffusion of heat to the surrounding atmosphere, thus effecting an economy of steam. At the same time acting, as it does, as a shield against interference by the force of the winds, the ejectors are better able to accomplish the circulation of the water in the cup. The danger of cup water freezing is greatest during cold drifting snow storms. At such times, the snow enters the cups faster than it can be melted, consequently it accumulates until there exists a condition of slush, and then circulation of the water and the heating of it is impossible. Of course under such circumstances danger is imminent. In a number of instances coming under my observation, conditions such as described, have necessitated the

rapid lowering of the holder to remove the accumulated slush, and snow, and replenish with water from the tank. It is quite obvious that at such times the cup guard would be an effective protection. It should be stated that snow accumulates in the cups only at points intermediate between cup-water heaters.

Five-ply rubber belting is usually requisitioned for a cup guard. It rests on short pieces of  $\frac{1}{4}$  in. x 1 in. iron placed about 1 ft. apart and bolted to grip sheet angle. It covers the cup to within a quarter of an inch of the shell rivets.

MR. H. W. ALRICH (New York): (Written discussion communicated.) The subject of Mr. Braine's paper is a serious problem, the importance of which has been but recently recognized. The full subject has never previously been discussed by the American Gas Institute, or its predecessor societies. The fact that Mr. Bradley and Mr. Morris were the first to establish a regular and systematic inspection and maintenance of holders makes it appropriate that some one from our organization should participate in this discussion.

On pages 781 and 782, Mr. Braine says, referring to masonry walls for protecting the base of steel tanks, "It has been found that these walls do not remain in intimate contact with the steel walls, considerable space appearing between the concrete, or brick wall, and the steel wall." Observations show that the width of this space between the outer surface of the steel tank and the inner surface of the wall varies somewhat with the temperature, and also with the season of the year. As concrete and steel are believed to have the same co-efficient of expansion, this variation seems to indicate that the tank and the wall are not acted upon by the same thermal influences. The temperature of the water at the bottom of a large holder tank does not vary greatly throughout the year, and we may reason that the steel plates in contact with this water, and sheltered by the protection wall, are prevented thereby from responding to the greater temperature changes of the atmosphere. The masonry wall, however, is exposed to the action of the elements, hence it would appear that while the

tank remains of a substantially constant perimeter, the masonry wall is contracting and expanding. We might now form the conclusion that protection walls built in winter would behave differently from those placed in summer, but observations do not confirm this. Nevertheless, while our theory may not fully conform to the observed phenomena, the action is obviously the result of varying thermal conditions. It has been suggested that the protection wall might be built before placing the water in the tank. When the tank was filled, in expanding under the hydrostatic pressure, it would develop tension in the masonry wall which would tend to keep it in absolute contact with the plating. This procedure has been opposed upon the ground that the masonry wall might be incapable of accommodating itself to the expansion of the steel tank, and thus be ruptured, possibly at numerous points. While dissenting from that view, I do not believe that the method would secure the desired result, because the contact of the masonry and the steel must be maintained either by the adhesion of the masonry to the steel, or by circumferential tension in the wall. The adhesion of cement, or concrete, to the surface of a steel tank, unassisted by a mechanical bond, cannot continue and I believe that unless the masonry contained a prohibitive amount of steel reinforcement, the ring tension would ultimately lapse through fatigue.

Personally, I do not now believe that masonry protection walls are either necessary or helpful. With our present knowledge, we cannot say positively that they are a protection. We do know that they may be a menace. There can be little advantage in enclosing the base of a steel tank which stands entirely above ground, and I believe that a fill of good loam, or clay, is all that is required for a tank depressed below the surface. I have examined two tanks, both of which had been in service some 20 years, one of which was protected by a fill of loam, and the other by clay embanked against the portions below the ground level. Both of these holders were located upon ground lower than the environment, and upon

which water accumulated after storms. However, both of these tanks were found to be without rust, or corrosion, at or below the ground line. In addition to the economy, a distinct advantage of this method is that it permits the inspection of the tank shell at a negligible cost.

Mr. Braine illustrates printed forms employed by a large gas company for reporting holder inspections. It will be observed that these forms are actually an enumeration of the parts of a gas holder. It is the practice of the Consolidated Gas Company to furnish the inspector with instructions, setting forth the specific defects, and forms of deterioration for which he is to seek, and upon which he must report. These instructions were compiled from an extended experience, and outline memoranda thereof are furnished for the PROCEEDINGS. Comparing the memoranda with Mr. Braine's paper, there will be noted some items not discussed by him. However, I happen to know that in practice Mr. Braine gives these matters full attention.

The accumulation of rubbish in the bottom of holder tanks is a matter of great importance. There are many holders that operate under such conditions that the outer section is being frequently landed, while the inner lifts may not touch the landing blocks in years. This may result in the outer section keeping its own path clear, but in the building up of a mound of rubbish inwardly therefrom. These mounds of rubbish may reach such proportions and such a condition of stability, that when in the course of time the inner sections are lowered, they may be seriously damaged by coming to rest upon the peaks.

No part of a holder merits more careful or frequent inspection than the cups. In their normal operating position, they are usually at a considerable elevation above the ground. From this we might be led to believe that the lodging of obstructions, or the accumulation of rubbish therein, is infrequent and improbable. The fact is that tools, bricks, stones, dirt and other materials do somehow find their way into the cups.

Directly related to this point is a requirement which we rigidly enforce. We do not permit the storage of tools, fittings, extra rollers, tackle and other such articles, upon the platforms, galleries or crown.

Mr. Down has referred to the rubber aprons, or cup guards, with which a number of our holders were at one time equipped. I plead guilty to having removed them. In general theory, this device has much to commend it, but no such apron has yet been designed which possessed sufficient durability to justify the cost. I repeat, holder cups should receive careful and frequent attention.

On page 834, Mr. Braine discusses the very important subject of cleaning snow from the crowns of holders. Important, I have said, and I do believe it is very important. If snow be permitted to remain, it will gradually creep down the spherical surface of the crown and form in drifts around the top curb. Most of the creeping occurs while the snow is thawing, and the action of gravity is sometimes assisted by the wind. Through successive freezing and thawing, this snow accumulated at the edge of the crown may have become very much more compact, and hence heavier than before; it may even partially have turned into ice. If not then removed, the snow with further freezing and thawing, may build up a leg of ice adhering to the surface of the holder sections and extending from the crown down to and resting upon the grip below. This leg of ice may reach such proportions as to extend over the first grip and down the side of the next section to the second grip. This condition would most certainly result in the holder being badly damaged if it were attempted to uncup from a grip in contact with the leg of ice.

The drift of snow may also slide off from the crown like an avalanche, landing in the cups and carrying away the steam hose. It may fall upon the roofs of adjacent buildings and damage them. It may injure those upon the holder galleries, or upon the ground below. I do not believe that any considerable quantity of snow can be allowed to remain upon the

crown of a holder without the occurrence of some one or more of these things.

However, I have gotten the idea that the great diligence shown in cleaning snow from the crowns of holders arises from a belief that an eccentrically located snow drift could somehow cause the uncupping of the inner section. A very brief mathematical consideration of the factors involved will show that a snowfall sufficient to uncup a 4 or 5-lift holder would probably not be encountered even in the Polar regions.

It is not difficult to trace this belief to its origin. The inner section of any gas holder is in unstable equilibrium when uncupped from the next outer section. This is due to the fact that the metal in the crown locates the center of gravity, which is the center of mass, above the center of buoyancy, which is the center of displacement. This instability was somewhat aggravated in the holders built many years ago, by the practice of trussing the crowns, and by the diameters being large in proportion to the depth. Both of these features increased the distance between the center of buoyancy and the center of gravity. Further, those holders were not provided with the efficient guiding employed at the present day. Hence, when we consider their design, it is not surprising that the inner section, or single section, keeled over with slight provocation, and frequently wrecked the guide frame, which generally consisted of independent columns, independent because inadequately braced and tied together. This accumulation of snow upon one side of the crown, acting together with a high wind against the other side of the section, came to be recognized as representing a very precarious condition.

Mr. Cripps, in his book on the "Guide Framing of Gas Holders," published in 1889, in discussing holders of now obsolete design, makes this statement regarding snow, "It is a very dangerous tilting force when it lies on one side of the top." But, on the very next page, he sets forth in italics "Unless the resolved wind and snow pressure exceeds the weight of the outer lifts, the gas holder cannot tilt." Notwithstanding



Mr. Cripps' italics, this seems to have escaped general attention, nor does it seem to have been noted that if his formula were to be developed in connection with a modern 5-lift holder, such an occurrence as uncupping from snow and wind is unthinkable, even though three lifts may be resting upon the bottom of the tank. Now as I fear being misunderstood, I will repeat that I do believe that the snow should be removed from the crowns of holders, but I also believe that we should have in mind the exact reason why, and not require it or enforce it in observance of a somewhat mouldy tradition of what the result would be, should the immediate removal of the snow be neglected.

Mr. Thorn described the buckling of the vertical legs of the outer section of a holder by the vertical legs of the next inner section jamming against the grip, while the holder was descending. He does not enlighten us as to what happened to the inner section, which caused the vertical legs thereof to be buckled to such a considerable extent. A distortion of such magnitude as to inflict the damage which he describes upon the outer section only occurred through the application of a great deal of force. It could not have been the result of a gradual springing, but whatever the cause, the incident emphasizes the importance of frequent holder inspections.

Under the caption "Faults in Design," Mr. Thorn says that "Foundations are a part of the work always put out of sight and generally done before any active interest is manifested in the operation, and have received the most abuse and often the least expert supervision of any class of work known." While, of course, I cannot undertake to dissent from his remarks as far as they may relate to particular foundations which he may have in mind, I do most positively challenge the general application of his statement. As a result of an extended observation, it is my belief that the importance of proper foundations for gas holders has been fully realized for many years, and has received thorough study. We may criticize the superstructures of the gas holders built by our forefathers in the

gas industry, but they put their foundations in to stay, and I am glad to say that we have been following in their footsteps.

Continuing his discussion of "Faults in Design," Mr. Thorn treats of points so elementary in the execution of any structural work, that anyone unfamiliar with them, should not be permitted to exploit his ignorance in the building of a gas holder. For instance, a man who did not know enough to inspect all rivets and bolts, or to test the cups for leaks, would be worth more money wheeling oxide.

Mr. Thorn submits a design for a cup skimmer, by means of which he apparently expects to remove the oil from the cup water so thoroughly that the paint on the holder sections will not be discolored thereby. I am afraid that experience with the device would be disappointing, for we long ago discovered that the discoloring of paint cannot be avoided by any process of skimming water after it has been contaminated by oil. Further, the suggested device would be very difficult to employ for the reason that the level of the cup water varies considerably. Hence, if the skimmer cup be located at a level that would permit its being used under a wide range of conditions, we would be dependent upon human diligence in closing the angle valve, to prevent water being lost from the cups, in other words, it is not fool proof, and I believe that all such attachments are a menace to a holder. There are other objections to this cup skimmer upon which I shall not enlarge, but will close by saying that any results expected from it, can be accomplished to a better advantage in other ways.

#### MEMORANDA FOR HOLDER INSPECTION.

##### TANKS:

Settlement of tanks.

Leakage from brick tanks.

Contact of protection walls with steel tanks.

Conditions around bottom curbs of steel tanks, without protection walls.

Drainage of tank walk-around.

Deposit in tanks.

Corrosion at the water line.

Corrosion of walk-around.  
 Corrosion of back of standard supports.  
 Security of railings.  
 Leaks or weeping.

**GUIDE FRAME:**

Alignment of guide rails.  
 Corrosion of horizontal ties.  
 Corrosion of top of girders.  
 Corrosion of splice plates.  
 Condition of interior of cylindrical columns.  
 Missing rivets or bolts.  
 Security of ladders and railings.  
 Weep holes in cast iron columns.  
 Steam piping on contact with structure.

**LIFTS:**

Tightness of seams.  
 Corrosion behind ribband plates.  
 Condition of cup sheets at water line.  
 Condition of dip sheets.  
 Deposit in cups.  
 Condition of rivets attaching dip sheet to grip channel.  
 Life lines.  
 Large holders without grip-gallery rails.  
 Security of railings.

**GUIDING:**

Adjustment of rollers.  
 Lubrication.  
 Wear.  
 Bending of spindles.  
 Tank rollers and brackets missing.  
 Inside rollers.  
 Rust.

**GENERAL:**

Dirt and rust under paint.  
 Missing rivets, or bolts.  
 Tools, etc., stored on platforms, galleries, or crown.  
 Electric wires, etc., attached to structure.

MR. J. H. TAUSSIG (Philadelphia): I move a vote of thanks to Mr. Braine for his most excellent and instructive paper.

MR. GARTLEY: I second the motion.

MR. BRAINE: If there is no more discussion, there is just one thing I should like to get into the record, and that is that we do not depend on a measured volume in purging holders. We have a chemist on the ground the whole time, and we decide from his analysis. I put that tabulation in there as a matter of convenience, but we do not depend on it.

THE ACTING CHAIRMAN: You have heard Mr. Taussig's motion.

MR. VICTOR VON STARZENSKI (Schenectady, N. Y.): I should also like to move a vote of thanks to Mr. Thorn for his very interesting discussion.

MR. BRAINE: I second that motion.

The motion thanking Mr. Braine for his paper was then passed.

A motion was then passed thanking Mr. Thorn for his discussion of the paper and his lantern slides.

MR. WALTON FORSTALL: I move we adjourn.

The motion was seconded and carried.

THE CHAIRMAN: The meeting to-morrow morning begins at 9:30 o'clock.

Adjourned, 5:40 P. M.

## ILLUMINATION SECTION

Afternoon Session, Thursday, October 22.

MR. C. O. BOND (Philadelphia), *Chairman*, Presiding.

MR. C. W. JORDAN (Philadelphia), *Section Secretary*.

The Chairman called the meeting to order at 2 P. M.

THE CHAIRMAN: We will begin this afternoon with the paper on "The Physical Installation of Gas Arcs," by Mr. C. A. Luther, of Chicago.

### THE PHYSICAL INSTALLATION OF GAS ARCS.

The physical installation of gas arcs is of vital interest to all gas companies, and should receive a good deal of attention, not only by the management, but also by the fitter who executes the work. The fitter should be thoroughly familiar with the rules formulated by the company for instruction and guidance in the performance of his work. He should always bear in mind that such rules are not the arbitrary dictum of the employer, but that they have been drafted and decided upon after many years of experience of both employer and employees, and are intended for the mutual benefit and protection of both.

Every company has a right to require its employees to study and familiarize themselves with and to observe its rules; and every man who respects himself should work for his company as conscientiously and economically as he would for himself.

The fitter should first of all be made to realize that his position depends upon the prosperity of the company for which he works, and that the prosperity of both depends upon the success of his efforts to satisfy the consumers. When a fitter realizes this fact, he will do his best to install all arcs in such workmanlike manner that due credit for the installation will be given him by the management and consumer.

### INSTALLATION INSTRUCTIONS.

To install gas arcs properly, the fitter must necessarily be provided with instructions for his guidance. These instructions will quite naturally vary with the different installations.

The solicitor or representative who secures the signature of the consumer for the installation should not only know the piping rules of the company, but he should also be able to sketch a plan of the piping, if necessary, even to the outlets

DIAGRAM OF LOCATION OF LAMPS FRONT OF BUILDING		Use this code in locating lamps
	• Outlet	
	X Hang Here	
	⊙ Move Lamps from here to	
	⊕	
	Present Units	<i>4 St. Std.</i>
	Color of Ceiling	<i>White</i>
	Color of Walls	<i>Buff</i>
	Height of Ceiling <i>12 ft.</i>	
	Hang Lamps <i>10 ft.</i> above floor	
	REMARKS	<i>Straight As</i>
	<i>Every Line</i>	
	<i>= 3'</i>	
<p>Appliances specified on face of this ticket have been received in good condition and the work has been done satisfactorily</p> <p>Signed <i>John Jones</i></p>		

Fig. 1.—Shop work ticket.

where the units are to be installed. He should by all means see that everything is satisfactory, especially where extensions for outside arcs are to be made from existing outlets.

As the fitter is not a mind reader, the solicitor must indicate to him, in simple language and by a plan, the various locations where the lamps are to be installed. Furthermore,



to insure the units being hung where originally specified and to eliminate the possibility of the prospective consumer changing his mind, the solicitor should make all necessary diagrams or memoranda on his order in the presence of the customer.

#### SHOP WORK TICKETS.

The shop work ticket shown in Fig. 1 is used by the company with which the writer is connected, and was devised to eliminate the possibility of the consumer changing his mind after the fitter arrives on the job, and at the same time, it conveys to the fitter the exact locations where the units are to be hung. This diagram is printed on the back of the shop work ticket, and shows the present location of the units which are to be changed, existing outlets, and the location in which the lamps are to be installed. The fitter can, therefore, estimate the amount of material required to complete the installation before he leaves the shop.

#### INSURANCE INSTALLATION.

In some instances it may be good policy to make a diagram like that shown in Fig. 2. This form is attached to the shop work ticket for the guidance of the fitter, the same as Fig. 1. In this instance, it not only expedites the work of the fitter, but it is also of value to the solicitors in general, as for instance, in this particular diagram which shows an installation of 60 arcs that was made for the Underwriters' Salvage Company, a company that is operated by 65 insurance companies as a disposal station for materials damaged by fire and water. Prints similar to this can be shown to prospective consumers wherever there are doubts in their minds as to the installation of gas arcs affecting their insurance.

#### DELIVERY.

##### *Material.*

As soon as the fitter has received his hanging orders, with diagrams attached showing extensions and new outlets, he should get out the necessary pipe, fittings, etc., so as to elimi-



nate any return trips to the shop for additional material that was overlooked while making up his deliveries.

### *Tools.*

The fitter should also see that all necessary tools are sent to the job with the pipe and fittings, such as wrenches, cutter, stocks and dies for the different sizes of pipe he expects to run, and a vise if necessary, provided there are any extension lines to be run at that particular installation.

### PACKING.

#### *Glass and Lamp Cans.*

We have devised for our own use several types of galvanized cans (see Fig. 3) to transport our lamps and globes. These

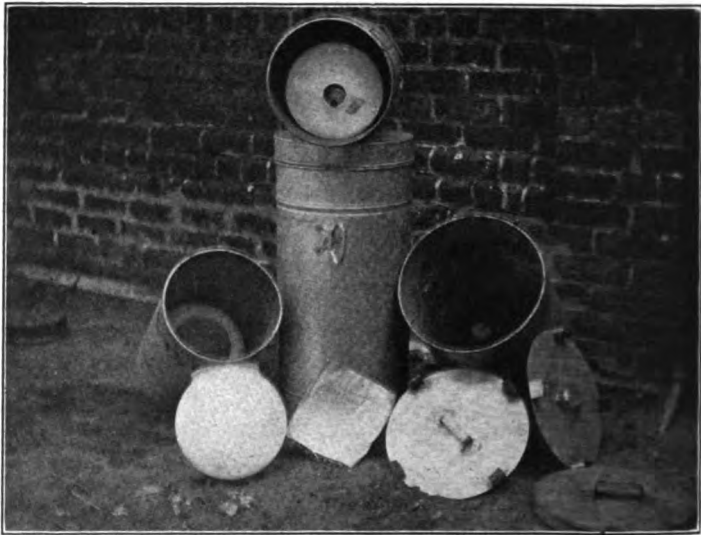


Fig. 3. —Cans for lamps and globes.

cans can be safely and conveniently packed on our delivery trucks, without any possibility of breaking or injuring their contents.

*Lamp.*

To assure the safe delivery of arc lamps without chipping the enamel or bending any of the parts, the fitter should take the precaution to see that the lamps do not come in contact with each other or any other material of a hard nature. He can easily eliminate these hazards by delivering the arc lamps in the original cartons. If no cartons are on hand, the units should be wrapped separately in blankets or padding especially made for the lamps.

It is not good practice to pack arcs in excelsior or straw as these contain a certain amount of fine chaff or dirt which is bound to get into the working parts of the units and cause trouble after the lamps are installed.

*Glassware.*

In packing glassware, the same precautions must be taken to avoid the possibility of having broken or chipped glass when the fitter unpacks it on the job. Careful packing of the glass will save the fitter a trip to the shop for replacements.

*Mantle.*

Great care should be exercised in placing the mantles in a safe place where there is no danger of any material crushing them. Damp cleaning rags should be kept in tins where they cannot come in contact with the mantle boxes.

## INSTALLATION OF INDOOR ARCS.

The following table gives in a concise form the amount of different size pipe allowed for extensions or regular piping:

Size of pipe (Inches)	Pipe allowed (Inches)	Number of gas arcs allowed
$\frac{3}{8}$	30	1
$\frac{1}{2}$	40	2
$\frac{3}{4}$	60	5
1	70	8
$1\frac{1}{4}$	100	15
$2\frac{1}{2}$	150	30
2	200	50
$2\frac{1}{2}$	250	100
3	300	150
4	450	250

Any ceiling 20 ft. high or over should have  $\frac{1}{2}$  in. drops so

as to allow for any larger or heavier fixtures than a gas arc that may be installed at some future date. The running line in stores should not be less than  $\frac{3}{4}$  in. pipe to the last outlet.

The riser in a cold basement should be located at least 4 ft. from an outside wall. If the owner wants the meter set on the outside wall, this can be done, provided, however, he builds a false partition of wood which provides an air space of not less than 2 in. between the partition and the wall.

The drop outlets in a store must run  $2\frac{1}{4}$  in. below an unfinished ceiling and  $1\frac{1}{2}$  in. below a finished one.

The fitter, upon his arrival to install arcs on existing outlets, should first ascertain if the drop is sufficiently strong to support a gas arc in safety, and whether the gas is turned on. When everything is satisfactory from these points, he should figure out the height his lamp should be suspended above the floor. Although the solicitor has specified on the order that the lamps are to be suspended at a given distance above the floor, the fitter may find conditions which require him to alter the distance specified. The height at which an arc lamp should be hung above the floor must be ascertained by measuring the distance from the floor to the lowest part of the lamp.

The following tables show the proper heights at which the arc lamps should be installed, to give the maximum distribution of illumination. All arcs should be hung according to these tables unless the installation is to cover some special duty, in which case instructions covering such installations should accompany the work ticket:

Upright gas arcs			Inverted gas arcs	
Height of ceiling	Metal ceiling plates required	Height of lamp from floor	Metal ceiling plates required	Height of lamp from floor
8'	Yes	6'	Yes	5' 8"
9'	Yes	7'	Yes	6' 8"
10'	Yes	7' 9"	Yes	7' 6"
11'	Yes	8' 6"	Yes	8' 6"
12'	No	9'	Yes	9' 2"
13'	No	10'	No	10'
14'	No	10'	No	10'
15'	No	10'	No	10'
16'	No	10'	No	10'

When the height of the ceiling permits, the unit should be hung as nearly 10 ft. above the floor as possible, but in no case less than 8 ft., unless there is some stationary desk or counter beneath the unit, so as to protect it from collisions. In no case should an arc be hung less than 12 in. from any combustible ceiling, and when hung 12 in. away, it must be protected by a metal ceiling plate above the lamp placed at least 1 in. away from the ceiling, so as to allow an air space between plate and ceiling. Where the ceiling is non-combustible, an arc may be hung 6 in. from it. By non-combustible is meant any ceiling that is plastered on tile or netting and not covered with wall paper.

After the fitter has hung the gas arc, he should get down from his step ladder and move away several paces so as to size up the lamp from different points to see that it is hanging perfectly straight, as a crooked lamp is always an "eyesore" to everybody. When he is convinced that there are no "angles" to his lamp, he should test it out to see that all the connections and lamp parts are perfectly gas tight, and that there are no leaks. Next he should see that the pilot light is properly adjusted, not so low that there will be any danger of it going out, nor so high that carbon will form on the lamp. The height of the pilot flame should not exceed  $\frac{3}{8}$  in. when the lamp is not in use, and 3 in. when the pilot is flashed.

Every inverted lamp should be equipped with a wire net at the time the lamp is installed, to guard against any broken glass falling on material or persons beneath it.

The fitter should be careful to see that the gas arcs are properly adjusted and that no broken mantles or glassware are on the unit before he leaves the premises, and as soon as the installation is completed, he should fully instruct the consumer how to operate the unit properly.

Where it is necessary to remove an electric fixture from the existing outlet, the fitter should use the following precautions before the arc lamps are installed: Before a disconnection is

made, either the fuse plug on the line should be removed, or the switch controlling that circuit should be opened. One wire should then be cut and properly insulated by wrapping the exposed end with rubber tape, and then covered with adhesive tape, taking care that no part of the wire is left bare. The other wire should then be cut and wrapped in the same manner. When the current cannot be cut off, great care should be taken not to allow the ends of the cut wire to come in contact with each other or with any metal part of the fixture or pipe, as this will cause a short circuit. The fitter must never allow the bare end of a wire to touch him while his hands rest on the fixture or pipe, as the fixture may be grounded, and he would receive a shock.

When arc lamps are installed in stores or factories where there is an automatic fire sprinkling system, the fitter should never hang the arc lamps nearer to any of the sprinkler outlets than 36 in. from the top of the arc, where the products of combustion escape. Actual tests have proven that an arc can be hung within 18 in. of a sprinkler outlet without melting the fusible plug that holds the water in check, but in every day work it is advisable to double this distance.

#### SPECIAL INSTALLATIONS.

Where a company expects to secure new business or to retain the business they already have, they must originate new equipments for the various classes of business they serve, or, in other words, they must anticipate the needs of the different consumers and be ever ready to assist them to perfect their various classes of work.

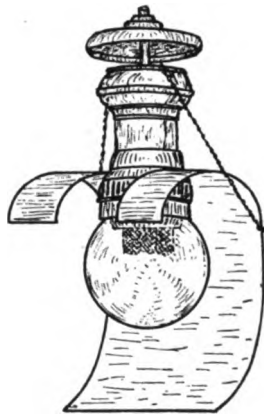
#### PHOTO EQUIPMENT.

There has been an increasing demand from photographers for a lighting equipment that would give them the same soft tones that they receive from a daylight exposure.

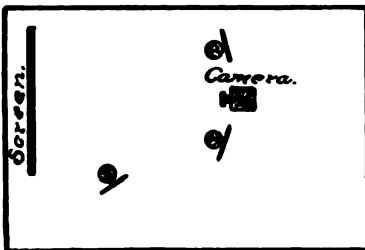
The photo studio equipment, as shown in Fig. 4, has met with great success, and as we have equipped a good many studios, it speaks for itself. The complete unit consists of a

regular three mantle inverted arc, equipped with a special reflector, our special "Daylight" globe and "Daylight" mantles. The reflector is coated with aluminum paint on the reflecting

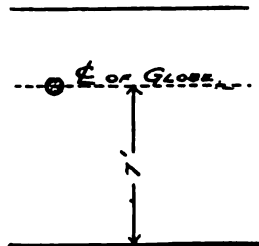
## FOR PHOTO STUDIO.



*Location.*



*Height.*



*C.A.L. 1917.*

Fig. 4.—Photographic studio equipment.

side, and black on the back so there will be no cross reflections that may strike the lens of the camera. This reflector is so

constructed and attached to the unit that it can be so adjusted that the light can be reflected wherever desired by the photographer.

To properly equip a studio, there should be installed three of these units located as shown in Fig. 4.

#### "DAYLIGHT" GAS ARCS.

Another great success we have met with is our "Daylight" gas arc. This unit is similar to the "Photo" equipment, but has a mirror reflecting shade instead of the semi-parabolic shade as shown on the photographer's unit.

The special "Daylight" globe and mantles gives us as near daylight results as can be procured, proven by the fact that this type of arc has displaced practically all other kinds of so-called daylight producing units.

We have equipped practically all the colortype printing houses in Chicago with this unit and have just started to canvas and send pamphlets to all other kinds of business houses which require artificial daylight for securing true color values.

We have only been installing this type of arc for the past two months, and up to date have installed over three hundred and are constantly receiving requests to install additional units.

#### DAYLIGHT INSTALLATION.

Fig. 5 shows a typical installation of the "Daylight" gas arcs in the printing house of the Regensteiner Colortype Company, Chicago, Ill. As can be seen from the picture, these units are installed directly above the presses for the reason that it is very necessary that the printed sheets have true daylight illumination on them as they come off of the press so as to allow a perfect check on the coloring of their prints.

#### OUTDOOR ARCS.

The same piping rules given for the installation of indoor arcs should also prevail on the installation of outdoor arcs.

In all instances, extensions for outdoor arcs should not be less than  $1\frac{1}{4}$  in. pipe.

No outside arc should be installed less than 12 in. from any combustible material, such as awnings, woodwork, etc. These measurements should be taken from the top of the stack where the products of combustion escape, or from the



Fig. 5.—“Daylight” installation.

outside of the globe. The sagging of awnings should be considered and measurements should be made so that, at all positions of an awning, the lamp will never be nearer to it than 12 in. Special attention should also be given to the installation of outside arc lamps near glass windows.

The height at which an outside arc may be installed varies according to the use for which it is intended, but in no case



should it be hung less than 8 ft. above the sidewalk. The height can vary for special occasions, and these will be governed by the rules of the various companies. But it should be borne in mind that the higher the arc is hung, the greater will be the radius illuminated, but at the same time if a fair general illumination is desired with an intensive illumination directly under it, then the arc should not be hung over ten feet above the sidewalk.

All outdoor arcs should be securely fastened so as to eliminate any possibility of danger from high winds. If the extension is short, then there will be no necessity of braces, but if the arc extends over the sidewalk, then a brace should be provided to prevent the unit from sagging or swaying. We have found that chains are the best type of support for extending brackets, where there is a chance of attaching them to the building so as not to produce too sharp an angle. The chains will allow a certain amount of vibration to the unit and does not allow the short, sharp shocks that are produced when pipe or iron braces are used that hold the unit rigid.

If it is necessary to brace the unit from beneath, then the pipe or iron braces must be used, but these can be so attached to the bracket so as not to hold it absolutely rigid, which means a big saving in mantles and glassware.

When an outside arc lamp is being installed, the piping should be run, or changed if already in, to prevent the condensation from draining back to the house piping or meter. The piping should be so arranged that all condensation will be trapped outside of the building, with a drip consisting of  $1\frac{1}{4}$  in. nipple 6 in. long and equipped with a reducing fitting  $1\frac{1}{4}$  in. x  $\frac{3}{8}$  in. If the drip is 7 ft. or more from the sidewalk, a  $\frac{3}{8}$  in. short nose pet cock can be used; if less than 7 ft., the opening should be closed by a special  $\frac{3}{8}$  in. plug.

In case connections are such that some of the condensation collected will drain to the head of the lamp, a special concealed lamp drip should be used and equipped with a pet cock so it can be drained easily.

If more than two arcs are installed and the length of ex-

### **SQUARE TYPE BRACKETS**

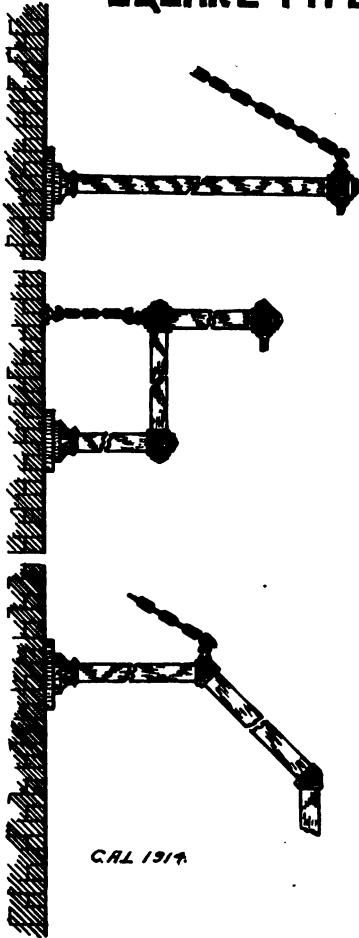


Fig. 6.—Square top brackets.

posed pipe trapped is excessive, then the length of the pipe drip should be increased.

#### **SQUARE TYPE BRACKETS.**

Fig. 6 shows different forms of brackets than can be made up with the special 45 deg. and square head fittings. All the

pipng that extends from the building can be covered with square galvanized casing 2 in. in diameter. This type of bracket is supported with  $\frac{3}{16}$  in. plain link galvanized chain, painted the same color as the brackets.

## SAFETY FIRST SUGGESTION.

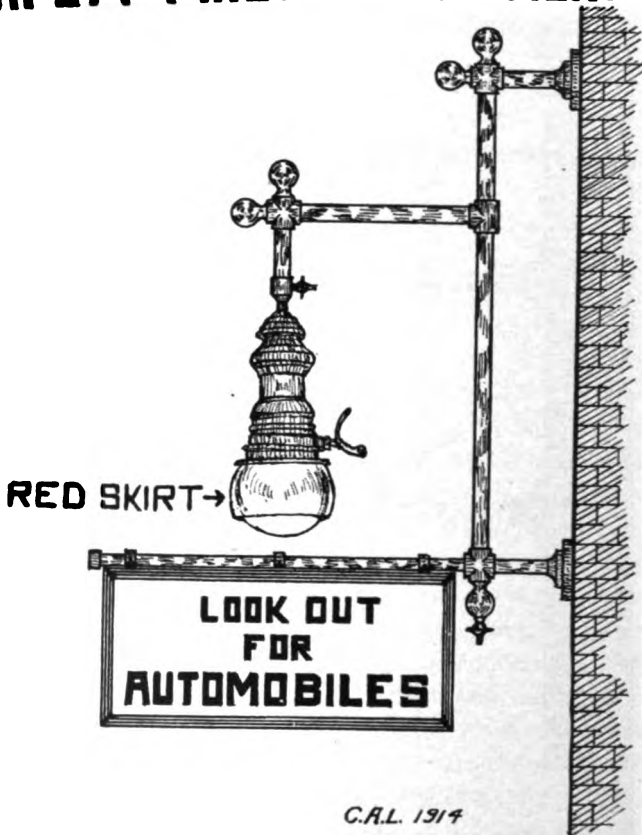


Fig. 7.—Safety first suggestion.

We are making this casing in 2 ft. lengths with interlocking ends, that will permit us to extend any length desired.

From actual test, this type of bracket has eliminated a good many frost complaints in the winter months, due to the insulating effect of the casing around the pipe.

#### SAFETY FIRST SUGGESTION.

See Fig. 7.

**THE CHAIRMAN:** I would suggest that you lay a little emphasis on the "Daylight" paragraph.

**MR. LUTHER:** We do not claim absolute daylight, but very close to average daylight conditions. The first installation in Chicago was strictly competing against electricity. At this first place we put in a few of the regular lamps, but they were ordered out because they did not match the electric units. This plant was using practically electric daylight units throughout. We secured permission to make a series of experiments that took us more than two years before we convinced them we could produce the kind of illumination they required. I might state that their manager is a color expert. He was hard to convince that we had something he needed, but eventually we arrived at the combination of the globe and the mantle that gave us approximate daylight, and he was very enthusiastic over it when he saw it at our office. When we installed it in his plant to allow him to make comparisons, he was not so enthusiastic; he would not say anything, and he walked back and forth between the gas and electric units. Then, after he had matched the colors between the two units and "Daylight" about a dozen times, he was convinced. He gave us an order immediately to install our daylight lamps. To-day there are over seventy-five in this one place. From that one installation, we have branched off to practically every other printing concern in the city of Chicago, and one solicitor has been doing it all. He was thoroughly enthused over the proposition we had, and understood the requirements of the different concerns, and he has put in up to date (which is a matter of practically three months) over 800

"Daylight" gas arcs. He confined himself first to the colortype printers, then branched off to large clothing and silk concerns. In several instances, where they operated their own electric plants, by putting in "Daylight" gas arcs, he made energy available for power. Every one of these installations is practically a testimonial, because different concerns are referred to them every day, and by this method, we secure a good many installations.

We claim a superior quality of light that approximates daylight nearer than any light our customers have ever used. For instance, in one colortype plant, the Hennebury Company, which is known all over the country, they generate their own electric light and power. I visited their plant with several other gas men about a month ago, and learned a lot of things. Their manager was very enthusiastic over them, and he took us over to some color sheets that they had been printing for outside covers of magazines. He called our attention to a little dot on the sheet that the average person would never notice, and said "You see that dot? Well, that is the day man's work." He took us over to another pile, and showed us one with two dots on it, and said, "That is the night man's work. Before we put in these daylight lamps, we never had to put any dots on them at all, because we could go from one to the other and tell the night man's work." I was very much surprised, when I was leaving, to find out that he was an electrical engineer. (Applause.)

THE CHAIRMAN: Those of you who have this paper will notice that there are other features a little later in the text which Mr. Luther has not brought out, but which are of importance, and show a new direction for the use of gas.

MR. NORMAN MACBETH (New York): I would like to ask Mr. Luther if he would prepare a paper or series of articles on some of these many Chicago installations, bringing out the average installation and maintenance costs, as well as some of the other interesting points resulting from their wide experience, which would be helpful to other gas companies through-

out the country, that they may know how to take this work up profitably.

Real information on installation and maintenance costs is not easy to secure, and, unfortunately, there are not many gas companies that will pass this information along even when they are satisfied with their own results. A paper of considerable value of this kind, but relating to electric units, was presented by men from the Commonwealth Edison Company of Chicago at the recent convention of the Illuminating Engineering Society. Very complete information was given on many factory installations of electric lamps. The rental and maintenance contract was described, installations were analyzed and a very complete idea was given in such a manner as to be available in other cities where it was desired to take on a similar proposition. The gas men are older and have more experience in this work, but the "help-the-other-fellow" kind of information is not readily available. The blanket of secrecy is still tightly drawn, and for some reason which I cannot understand. Assuredly your competitors—if gas and electricity are ever in competition—know what you are doing and how, and the giving of this information would help to bring more good business propositions before the consumer, to the profit of gas companies all over the country, who are surely not in competition with each other.

Mr. Luther has shown, and we all know that they are doing a great deal of very excellent work in Chicago. We have heard so much about good consumers and poor consumers,—I mean from the standpoint of gas lamps and gas consumption. A gas lamp may be too small to be considered useful to the gas company, because of low consumption. That should be an interesting point from the gas company standpoint on these "Daylight" lamps. I had not noticed the spacing of outlets for these lamps nor whether they were used for general illumination or merely for local illumination, but I should judge, considering the absorption of such a glass, that it would receive instant endorsement by companies not interested in small con-

sumption units. A 5-mantle lamp with 17 cu. ft. per hour, delivering as much light as a Junior burner, would certainly be free from the criticism that it was not worthy of a gas man's attention. We may expect to see fewer flame burners in installations where this color appeal can be made. I would like to ask what sources of light were in use in these establishments before the "Daylight" lamps were put in, whether incandescent gas or electric lamps?

This matter of accurate color identification is very important to many lines of industry, and is actually worth many times its cost. I called on a color printing man the other day, and asked him what he did to insure proper work with his night shift, and he said he trusted to Providence. It is not only the mixing of colored inks, but the distributing of the ink to the paper, on jobs running several colors, and at night it makes considerable difference whether or not the job runs through as it should. Then when morning comes, they have the answer.

There is one point to which I do not see any particular reference as to the kind of glass used. Blue glass is referred to, but practically all these "Daylight" and so-called "Daylight" glasses are blue, and when casually examined, they appear as blue glass. However, there is a great deal of difference between blue glasses in their light transmission characteristics. Two pieces of "blue" glass are in the technical exhibit downstairs, one of which is properly selective in its absorption to result in an artificial daylight, and the other is a blue signal glass; both are lighted with the same lamp. The blue signal glass still appears blue, while the specially made glass appears white.

MR. J. P. HANLAN (Newark): I think Mr. Luther's presentation of this paper is a mighty good one, and, thanks to him, we are getting in shape to try out the "Daylight" arc. We have samples on order, and hope to make a number of installations in our territory, as we have silk mills and dyeing establishments, as well as other plants, where we feel this arc has

a place. I think we all agree that there is a right and a wrong way to install gas arcs, whether indoor or outdoor arcs. I believe Mr. Luther has given us some information here that will be a big help to us. A gas arc is not sold until it is properly installed, because, unless so installed, it cannot give the customer satisfaction.

Speaking about outdoor arc lighting, it would pay anyone, while here, to go around New York, and see some of the examples of outdoor lighting that have been made within the past eight months. I was out the other night, and saw a number of places having from six to twelve outdoor arc lamps, and they were giving an outdoor lighting service that would compare with any. Many of these outdoor arcs were put up alongside of nitrogen-filled lamps. Outdoor arc lighting, if we make the proper installation, is very profitable business for the gas company, and I feel sure that the business is to be had if we will go after it and make the installation in the proper manner.

Mr. J. P. CONROY (New York): I think there cannot be too much stress laid on some points given in Mr. Luther's paper. One is in reference to the manner of handling lamps. We have found it necessary to enamel nearly all gas lamps, as it saves the chance of discoloration or rusting. Keeping the lamps in the corrugated paper cartons or wrapping them to avoid injury is important. What is still more highly important, as we have known for a long time, is the danger of chaff, dust from excelsior or straw, getting into the lamp. Many a lamp installation has given trouble for months, either with the pilot light or the lamp proper, through some foreign substance getting into the lamp between the time it was packed or unpacked until it was hung, and this chaff or straw will burn inside the lamp and form into a sort of ash, and stop up the small passageway. A great many troubles have been traced directly to that, and too much care cannot be taken in that respect.

In reference to Mr. Hanlan's remark about seeing outdoor lamps here in the city, it seems to me that a large majority



of the gas companies have lost sight of what outdoor lighting really does for them. In these times, nearly everybody has some form of indoor lighting, and when you are selling indoor gas lamps, you are more or less replacing some other kind of gas lighting. Here in New York, about 3,500 outdoor lamps have been installed in the last six or eight months, and in nearly every case, in a place where they did not use any other kind of outdoor lighting before, meaning absolutely new business. It seems to me, that that is a thing a gas man should look for to increase the sales of gas on his old mains and services, and it is my belief, and I think after carefully considering the matter, you will all feel of the same mind, that good outdoor gas lighting is the best business to develop on old mains and services.

MR. G. S. BARROWS (Philadelphia): I would like to know if the drip for arc lamps illustrated in the paper is of sufficient capacity under all conditions, and if it is so designed that it will safeguard the pilot also.

What means are used for automatic or distant control of lamps; and if it is in order for Mr. Conroy to discuss it at the present time, I think it will be interesting to know something about the use of the mercury valve, which, it seems to me, is a highly desirable device, if it is reliable under all conditions. If it is not reliable under all conditions, may Mr. Conroy tell us where and when it should not be installed?

MR. D. E. KEPPELMANN (San Francisco): I am looking for information. Mr. Barrows mentioned distance lighting, which I am very anxious to hear of, and also in addition to that, I wanted to bring out a discussion on the question of maintenance of gas arcs. In that discussion I am anxious to learn whether it is advisable for a gas company to put out a number of gas arcs at a certain small rental. If any of the members are renting gas arcs in this way, do they charge the same rental to all consumers, whether they rent one or several dozen? Is it advisable to have a sliding scale? We have in San Francisco 10,000 arcs on the system at the present time

which we own outright and rent to the consumer, whether he rents one or two dozen arcs, at 50 cents for each arc. Is it advisable to charge the same amount for each arc, or should there be a sliding scale?

MR. CONROY: I have been asked to describe the mercury valve. The operation of this valve seems very simple to me. The arc lamps have a side valve, made removable so they can be exchanged if worn or leaky. This mercury valve was so designed that by simply removing the bolt on any present type of indoor or outdoor lamp, you can take off the old valve, bolt on a mercury valve having in it a little well about  $1\frac{1}{4}$  in. in diameter and in depth. In this well, there are four tubes in which the gas passes from the main supply pipe up into one main tube and down through the center to feed the burners. We place in this well 4 ounces of mercury, and a little double float is dropped in. When the float is dropped clear down, its two ends dip into the mercury and prevent any gas from passing through. The supply to the pilot lights leaves the valve before it gets to the well, so that with the float down and the gas all cut off at the mercury well, the pilot can be maintained. We have gauged this float to lift at a pressure of about 1.2 to 1.5. In the pipe leading to the lamp, we place what is known as a by-pass, on the side of which is a small passageway which can be regulated by a screw, allowing a very small amount of gas to pass. With this by-pass, one or more arc lamps can be operated. You simply put the mercury valve on the lamp, turn on the gas and adjust lamps in the regular way, then shut off your main valve and adjust the by-pass, so that the gas passing through the line of pipe will maintain the pilots. You understand those pilot lights consume all the gas that passes by the by-pass valve; therefore, it does not build up a pressure in the line of pipe to exceed 1.0. At any time when you throw the main valve on, the full pressure, whatever it may be, 2.5, 3.0 to 4.0, instantly this pressure lifts all the floats in the mercury valves, and the pilots being already lighted, instantly light every lamp. When you turn off the main valve

again, you shut off the main supply of gas, the pressure in the line pipe drops and the mercury floats drop, shutting off all the lamps, but still leaving the pilot lights burning.

One of the beauties of this system is that you can operate it from any distance—several hundred feet. No distance seems to be too great, because you don't bleed all of the gas out of the pipe.

We find that a slight evaporation of the mercury takes place, so that it may be necessary once every three months to put a little more in. The only other objection I have heard to these valves was within the last day or two; someone said they found an outdoor lamp swinging in the wind, and there was danger of the mercury spilling into the tube. I do not know that that would happen, but we are now considering the construction of a rim to prevent any spilling.

The valve will operate perfectly on any of those lamps, any distance and any number, so far as we have been able to try them out, and you can utilize any present line of pipe, indoor or outdoor, providing no other supply is taken off.

MR. A. R. BEAL (Newburgh, N. Y.): Were those mercury valves adaptable to single burner units?

MR. CONROY: These are not as yet adapted for single burner or other kind of lamps, but I know of no reason why those valves cannot be readily adapted for almost any lamp.

THE CHAIRMAN: This is all very pertinent to your subject, and I hope you are enjoying it.

MR. BARROWS: Will Mr. Conroy go a little further, and tell us whether or not he knows of any cases of annoyance due to the presence of dirt in the mercury?

In mercury safety seals, I have found that the mercury will sometimes collect on the particles of dirt, so that instead of a fluid, it becomes an aggregation of globules of mercury that permits the passage of gas.

I have heard in some cases where there is a noticeable variation in the gas pressure, due, perhaps, to inadequate piping, that when the number of lamps is increased, the

pressure will drop more than the differential necessary to operate the valves, and some of the lamps may be extinguished. As the lamps are extinguished, the pressure will build up, and the lamps will be again turned up. If this is the case, we should be certain that our piping is adequate. Will Mr. Conroy tell us if he knows of any such cases?

MR. CONROY: In our experience, we have not found that anything gets in, because the gas itself does not pass through the mercury. It passes through four tubes and comes up to the main tube. The mercury acts only as a seal. We have figured that when the pressure is below 1.0, it is hardly possible to use inverted burner lamps. In our experimenting, we found that from 1.5 to 6.0 had no effect on the valve whatever. There is no reason why we cannot weight those floats to make them operate all right at even higher pressures.

MR. MACBETH: I judge from this part of the discussion, that the General Gas Light Company has overlooked one possibility in putting out this mercury valve, namely, that it is also a good service indicator, depending upon how pilots acted in controlling this valve. As we already know, there is a vast amount of trouble in keeping pilots lighted. We believe that where a pilot is adjusted with the gas pressure at 4 to 6 in., and that the pressure afterwards drops 50 per cent. to 2 or 3 in., the pilots would probably go out. Now, with the mercury valves, the pilots are adjusted at about 1.0 in gas pressure, and if these valves fail to act, owing to pressure changes other than those used in their operation, it becomes an indication of poor service conditions.

MR. LUTHER: Mr. Keppelmann asked about the maintenance and the rental, and so forth. We have pilot lamps on a rental plan strictly. We, of course, once in a while, sell a lamp, but we try to talk every customer out of buying it; in fact, we don't want to sell a lamp. We have something like 100,000 arc lamps we are carrying on our books, that belong to the company, and we found that the system of charging for them on a sliding scale from 1 to 4, from 4 to 12, and so on

up, has worked out finely. It is natural that the consumer who has put in a large number of lamps should have the benefit of a different rental rate.

We have about 50,000 of the old standard arcs in use at the present time. These units we start at the rate of 50 cents each a month, and the inverted three-mantle lamp at 80 cents a month, and drop down. By charging 80 cents a month for the inverted three-mantle arc, we have been saved the necessity of renewing a good many of the old standard arcs. As Mr. Macbeth brought out, rental vs. selling was discussed at the National Commercial Gas Association meeting last year, and from the discussion, you could see that there was quite a diversity of opinion; in fact, practically everybody had a different opinion. Naturally, there were many men who were selling arcs.

With the rapid advance made in the last few years in new types of units, it seems to me that it would be poor policy to sell lamps, for we must all be in position to take care of our customers, and on a rental basis, if the customer is dissatisfied, you have a chance of keeping him satisfied by good maintenance, and as a last resort, putting in a newer type of lamp. If you sell the lamp outright, he has an investment, and nine times out of ten, that looks like a mountain to him. He cannot see the necessity of throwing away the old lamp and paying for a new one.

THE CHAIRMAN: I am pretty sure I have seen many outside arcs that, by their looks, were not on maintenance nor rented.

MR. G. W. THOMPSON (Chester, Pa.): I would like to ask Mr. Luther if he will tell us of his three-months-free proposition. At Chester, we work on a three-months-free plan, charging the customer for nine months service, and giving the summer months without charge, and in addition to that, so as to overcome idle lamps during certain periods of year, we allow a discount of 10 cents on maintenance charges, per 1,000 cu. ft. of gas burned, providing 2,500 cu. ft. or over, are

burned. This has been the means of keeping quite a number of our lamps in use during the summer months.

THE CHAIRMAN: Mr. Luther, you might sum up now, if you care to do so.

MR. LUTHER: Mr. Macbeth spoke about a paper on the cost of lamp installations. Personally, I think it would be a mighty fine thing to have such a paper. I do not think that he meant exactly to confine it to the cost of the gas alone, but to make comparative costs, take average electrical installations, for instance, as compared to gas installations. If a paper were written along those lines, I think it would enlighten a whole lot of us.

In reference to the spacing of the "Daylight" arcs, we can go into a factory and space the lamps so they give a very good general distribution of illumination.

Mr. Macbeth wanted to know what units were being displaced by these arc lamps. Up to the first of the month, we have been keeping an accurate record—in fact we are doing it now, and expect to continue doing so, as it gives us some very interesting information. By installing 800 "Daylight" arcs, we displaced over 1,500 electric lamps, and 2,800 arc lights. The electric displacements comprise carbon and tungsten lamps, "Daylight" arcs and nitrogen lamps.

Mr. Hanlan brought out a subject that I think everybody should heartily agree with, and that is, that we surely have to get out after that kind of business. It is a well known fact that if we want anything, we have to go after it; we cannot sit down and let it come and expect it to keep on coming. If we get after the lighting, especially the outside lighting, we are bound to get it. That has been demonstrated right here in New York City.

Mr. Conroy made the remark that somebody had told him about the chance of the mercury spilling. I think he got that direct from Chicago. The other evening I was explaining to Mr. Humphrey the difficulties we had experienced on some of our installations from the mercury slopping over into the

valve proper, or into the tube. But we install our arc lamps so that they can do a lot of swaying, as we found by so doing we not only reduced our mantle breakage, but also our glass breakage. Naturally, when the lamps swing so much, the mercury is bound to spill. This spilling, I am told, can be very readily overcome by simply extending the tubes or making the inner tubes longer, so as to minimize the possibility of the mercury slopping over into the tubes.

Mr. Barrows asked about the drips as mentioned in my paper,—whether they were proving satisfactory. We have been using these drips for some years, and in the exceptionally cold weather of 1912, we had very little trouble with them. These drips simply take care of any condensation that might form between the building and the lamps proper. Of course, all installations have very large drips located at an accessible point, that take care of all other condensation.

Mr. Thomson spoke about the rental plan of three-months-free. In Chicago, we allow three months free,—June, July and August. As Mr. Thomson brought out, it was from heat alone that we experienced any trouble at all. There are lots and lots of consumers, especially the smaller ones, who close their store while it is practically daylight. They have no use for any artificial light, and consequently, if we charge them for the lamps during those months, they would naturally order them out. We have very few removals in the summer time, and I think it is due to allowing the three months free. (Applause.)

THE CHAIRMAN: We owe a vote of thanks to Mr. Luther for the paper which he has kindly prepared and so thoroughly discussed.

## SYMPOSIUM ON ILLUMINATION.

THE CHAIRMAN: (Introductory remarks as Chairman of the Committee on Illumination.) By looking through the records, it will be found that no illumination section has thus far been held by the Gas Institute or its predecessors, so that there was new ground to break. One of the first things to be

considered was whether there existed any other committee in the different gas associations having the duties which might be considered as belonging to the Committee on Illumination.

I found that there were six committees of the National Commercial Gas Associations which might be considered as having duties related to illumination, and that two of these at this date had proceeded so far with their work as to define their character and scope. These two are deserving of great credit, and have been under the leadership of Mr. R. F. Pierce, in educational work on the subject of illumination, and under Mr. L. R. Dutton, in the "Gas Equipment of the Home." The six are:

(1) A committee on indoor lighting; (2) a committee on outdoor lighting; (3) a committee on the gas equipment of the home, which includes lighting; (4) a central development bureau, whose statistical department is engaged in the collection of data on gas lighting which would be of great value to our industry; (5) a committee on salesman's handbook, which would, of course, be expected to contain information on illumination; (6) the educational bureau.

It seems undesirable that committees, each working for the good of the same industry, should duplicate effort, with a possible result of different conclusions. It is desirable, therefore, in opening this subject for discussion, to state that we have met here for the purpose of discovering in what way, if any, this Committee can be of service; and in so doing, I recall your attention to the report of the Technical Committee to the Board of Directors, in which a session of this nature is considered experimental. Whatever else we may conclude, it is perfectly evident to me that the impulse leading to successful work on the part of the Committee on Illumination must issue from, and be demanded by, the members themselves. This will give the assurance that those in the audience speaking deliberately for their companies, are willing to stand back of their recommendations with an expenditure of time and money, if



need be, in order to accomplish an increase in our service to the public in more and better gas lighting.

It is possible that many came here to-day with the thought that they are to hear new data, or to have retailed to them candle-foot measurements, or a discussion of direct and indirect lighting. All such will be disappointed. Such papers have not been given to this Institute in great measure, but they have been given, and I will recall to your minds some of them.

In 1906, Mr. V. R. Lansingh, fresh from his participation in the forming of the Illuminating Engineering Society, enthused with its aims and with what he conceived it ought to do in making our product more useful to the public as a light giving source, came before us at Chicago with a paper on "The Standardization of Gas Mantles." In this paper he outlined the methods by which competitors were succeeding. He explained to us some of the things which we should do in order to share in the success. Mr. Lansingh's paper received about a minute and a half of discussion and a vote of thanks, and although a motion was made that it be referred to the Committee on Candle-power, in discussion, this motion was voted down, and nothing happened of value to this Institute from his efforts.

Two years later, in 1908, Mr. T. J. Litle presented a paper on "Better Gas Illumination," and in the discussion Mr. Hare struck a keynote in advocating that the best place for this to begin was in our own show rooms and windows, and by making sure that our salesmen were educated in the principle of good lighting.

In 1909, the Committee on Utilization of Gas Appliances, while not extending their report to the use of illuminating fixtures, yet made one statement which is of direct interest at this point, namely: "The advantages to both the gas company and the manufacturer in the adoption of a standard design which would be practically unchanged from season to season are obvious," and they went on to say that, while some people might consider such standardizing of apparatus would result

in loss of inventiveness and ingenious design, yet the Committee regarded this as an invalid objection, compared to the results which would be obtained for the industry. It is conceivable that the same objection would be equally invalid against standard designs of gas fixtures and units for different classes of illumination. We must remember the persistent vogue of the dining room dome.

In 1909, we had also an excellent paper by Mr. Norman Macbeth, on "The Practical Application of Illuminating Engineering," in which strong emphasis was laid on the injury to good service in incandescent gas lighting from pressure changes in gas service. Mr. Macbeth analyzed some of the requirements of good service for lighting, and stated, "A standardizing committee of this Institute, acting with the manufacturers of gas lighting accessories, would seem to be a necessity."

Later on, in 1910, we had a paper by Mr. Thomas Scofield on gas lighting, and, as you will remember, in 1913, there was a joint session with the Illuminating Engineering Society, in which there were presented to us excellent papers by Messrs. Millar, Luckiesh and Luther.

The papers above mentioned constitute the information that has been presented to this Institute in past years by the most expert men we could command, written and delivered in the years of their best enthusiasm. How have we received this information? Has it provoked us to hard work for better gas lighting? Has it impelled us to so yearn for success that, with science and method, we set about improving our lighting conditions in the faith that the pleased public would rally to our support and ask for more of our kind of service? It is true that some of the larger companies have taken up good lighting and even scientific lighting, and it would be data of the greatest interest to us here to-day if we could hear to what extent those companies had been successful, compared with those who had failed to make effort in this direction.

What statistical data have we to show whether or not we

are losing the lighting business? Certainly none which has been gained by our gas associations, and yet this would seem to be a legitimate field of inquiry for a Committee on Illumination, and this inquiry will require the response and co-operation of every company approached. The only data of this kind, national in scope, which I have been able to obtain, is that published by the United States Geological Survey on gas output, and this I will read:

1908	M's cubic feet	
Coal gas .....	56,944,669	
Water gas .....	110,237,203	
Total .....	167,181,872	
Illuminating coal gas .....	32,485,571	
Illuminating water gas .....	76,804,546	
		109,290,117..65.4%
Fuel, coal .....	21,076,242	
Fuel, water gas .....	26,542,951	
		47,619,193..28.5%
Unaccounted coal .....	3,382,856	
Unaccounted water gas .....	6,889,706	
		10,272,562.. 6.1%
		167,181,872
1912		
Coal gas .....	93,369,001	
Water gas .....	134,707,509	
Total .....	228,076,510	
Illuminating gas .....	31,864,052	
Illuminating water gas .....	68,136,269	
		100,000,321..43.8%
Fuel, coal .....	57,829,320	
Fuel, water gas .....	54,561,527	
		112,390,847..49.3%
Unaccounted coal gas .....	3,675,629	
Unaccounted water gas .....	12,009,713	
		15,685,342.. 6.9%
		228,076,510

It would appear that in four years of the very period I have been discussing, there has been a loss of gas consumed for lighting purposes of 9,000,000,000 cu. ft., and a loss in per-

centage of the gas used for lighting purposes, from 65 to 44 per cent. This is an indication of the emphasis which has been laid by our industry on heating and cooking as contrasted with lighting. To drive home this point, the following electric figures given are eloquent. These figures indicate types of lamps in use.

	1907	1912
Arc lamps, public .....	289,391	351,858
Arc lamps, commercial .....	266,322	153,395
Total .....	555,713	505,395
Incandescent lamps, public .....	808,693	2,033,631
Incandescent lamps, commercial.....	40,637,304	74,450,265
Total .....	41,445,997	76,484,096
Nernst, vapor, etc., public.....	5,716	912
Nernst, vapor, etc., commercial.....	156,622	22,134
Total .....	162,338	23,046

It is seen that the electric incandescent lamps, over practically the same period, increased from 41,000,000 in 1907 to 76,000,000 in 1912, in the United States.

It may be that we shall find those in the audience who will dispute these figures, but whoever speaks, should speak from as large an experience in gathering data as the government report just shown.

But do we wish this apparent slump to continue? Is there any other outlet for our energy that so importantly advertises itself and our business as does this lighting outlet?

I have especially requested that there come before us to-day those who are deep pessimists on the subject of gas lighting. We need your story and data. For the love of candor, if there is any deep feeling in you to-day on this keenly important subject (and I know there is, or you would not be here), whether pessimistic or optimistic, please let it out, so we may know exactly where we stand.

This is not intended, however, as a mere "experience meeting," where steam is to be let off, reducing us to atmospheric pressure and incapable of further work or initiative. I have

hoped to see present here, men who could so adequately represent their several companies as to speak with the backing of their companies, of any plan of action which we may undertake. As I have stated, we do not wish to duplicate effort. There are those present who can inform us whether, in their opinion, any contemplated action would be duplicating effort. The question then is, what work is there for us to do, and does it seem of sufficient importance to warrant the continuance of this Illumination Section and of a committee on illumination to effectively sustain it? In order that we may not appear to be without definite subjects around which debate may center, I will state at least three possible avenues of work, and then open the meeting to your opinions:

(1) I believe it is possible to agree upon at least partially standardized lighting equipments for different kinds of service, which may be grouped in large classes, leaving room with each equipment for such decorative changes as may be necessary, but, at the same time, without seriously altering the quantity or distribution of light that issues from such equipment. I believe this is important, and I shall discuss it somewhat right here.

Our industry has for some 80 years, with increasing satisfaction and decreasing cost, furnished light to consumers. Even with the Geological Survey figures given above, it is not conclusive that we are losing the old consumers, who may merely be changing from open flame to incandescent mantle service, but more likely, that we have failed to gain the new consumers. We should be able to display for and to encourage the purchase by our consumers, of lighting appliances whose merits lie in their being *right*, and not merely in their being *new*. In much of the past history of lighting, there has been no true analysis of needs upon which to base design or invention. We have laid stress upon the beauty or the novelty of the thing we have supplied, and in doing this, we have done exactly what our competitors have done. This leaves open an excellent opportunity.

In a campaign just beginning in one of our large cities, I have read with pleasure this claim in the advertising: "We have studied the needs of this city and have designed a lamp which will meet those needs." Now, if it be true that such study has been complete and that the design has resulted from careful analysis of the needs, it is a safe prediction that the placements which will result are good for 15 or 20 years, with much fuller satisfaction to the consumer than usual and with his resultant good will. Such a placement will be able to give the laugh to the slogan, "If it isn't electric, it isn't modern," and it will lead to a healthy, candid examination as to whether modernity alone is a characteristic of such proven importance as to warrant the sacrifice of one's better judgment.

We have been engaged in the past few years in sounding the slogan of the "all-gas kitchen," and whether so intended or not, it seemed to many like the surrender of the remainder of the house. This error is being rectified with elegant effectiveness by the booklet of the National Commercial Gas Association, entitled: "The Gas Equipment of the Home." It makes widely evident the fact that a house may be of artistic design, harmoniously decorated, conveniently arranged, and that all these qualities are enhanced by the proper application of gas lights.

(2) The second topic which I suggest for discussion is that of devising a scheme for collecting data to prove or disprove the Geological Survey report before mentioned, and by means of which we may establish a basis in future to judge whether gas lighting is increasing or decreasing.

As I have stated, a committee of the National Commercial Gas Association is engaged in work which seems to cover this same information. This is, however, the proper place in which to emphasize to those engineering members of our industry the importance of co-operation in this work. It may be that it will be found necessary among the well-to-do, the middle class and the poorer class in a large number of cities.

to put in separate meters in random groups of twenty or fifty to establish the ratio between fuel and lighting consumption, and to study the use of open flame and incandescent burners. This entails expense, and we should discuss here whether or not the expense involved is warranted by the data needed.

(3) If we were to have a sub-committee on complaints, the analyzing and classifying of these complaints would soon show in what direction our engineering effort must be made in order to overcome these lapses from good service. Here, again, the engineering members of the profession are keenly interested. They are the ones who are responsible for the saturated or unsaturated condition of the gas; for the sulphur content; for the pressure variations; for the fluctuation consequent upon poor governing of intermittent appliances.

There would seem to be plenty of work to do. The present is the time for us in discussion to sift sentiment, condense opinion and to solidify our decision as to what work is best worth doing.

Gentlemen, the meeting is now open.

MR. C. M. COHN (Baltimore): I want to accept your challenge to discuss the subject of gas illumination from a practical standpoint. In the first place, I want to point out that the statistics quoted of the United States Geological Survey do not reflect at all on gas lighting as such. The quantity of gas sent out in Baltimore during the day light hours, figuring from 6 A. M. to 6 P. M., is greater now than the quantity sent out during the night hours. Following your reasoning, that indicates a decline in the amount of gas used for illumination. As a matter of fact, although the quantity of gas sent out during the daylight hours is greater than the quantity sent out during the night hours, there has never been a year when the quantity sent out during the night hours has not increased over the preceding year. It might be correctly reasoned, therefore, that the quantity of gas used for illumination in Baltimore, is constantly on the increase. I think it is.

Now, you have extended a special invitation to the pessi-

mists. I do not accept your invitation as such, because I am not in that class. I do not want to be understood as responding on behalf of the pessimists. Artificial gas, up to a few years ago, was commonly referred to as illuminating gas. That designation has been criticised lately on account of the very large quantity of gas which is used on a heating basis, and this condition has perhaps caused the impression, too, that the amount of gas used for illumination is declining. I think that is not a proper inference. It simply indicates that artificial gas for illumination is now being used very much more efficiently in the incandescent burners than it was before in the open flame, when the candle-power was the main consideration and not the heating value of the gas. As to the future of gas lighting, I feel that the first way to insure the more extensive use of gas for illuminating purposes, is to take such steps as may be necessary to insure good lighting service from the present gas installations. In other words, it is a serious thing in the gas business to lose any gas lighting business because of bad service. Bad gas service may not be due to failure on the part of the gas company to do the things which it may be strictly required to do. It may be traceable to the fault of the consumer in not making proper provisions for gas lighting, but whatever the reason is, it is incumbent upon the gas company, as far as practicable, to see that consumers have good gas lighting, if they have gas lighting at all, and not lose business because of bad gas lighting conditions. In that connection, I think it is highly important, and in fact an obligation on the gas companies, to urge, wherever possible, the more extensive use of the incandescent gas lighting, and the elimination, as far as practicable, of the open flame burner.

I think it is also important to have information, as far as it can be gotten without too much trouble, as to the amount of gas actually used in various cities in open flame burners. That is information which is being asked for in places where the question of whether gas should be on a candle-power basis or a heating value basis is under consideration.



THE CHAIRMAN: Have you any accurate method by which to determine that?

MR. COHN: It could be done by making a canvass of consumers, taking blocks of (say) one hundred or more in various sections, so as to get a fair average of the general conditions existing.

THE CHAIRMAN: Are you able to distinguish or tell easily the difference between fuel and lighting consumption in your city?

MR. COHN: The main check we have on that is the amount of gas sent out during the daylight hours and the amount of gas sent out during the night hours.

I would like to hear to-day something about how we can minimize the pilot troubles we have had. They are very disagreeable to the consumer and reflect seriously on the practicability of gas lighting and are a considerable expense to the company.

MR. NORMAN MACBETH (New York): One thing I have feared from my close interest in gas lighting and my observations from time to time, is that a great many of the gas men of to-day have buried gas lighting. They are through with it. There is one point, however, in their duty to their former customers, which they should not overlook, and that is (I quote Mr. Wakeman, General Manager of the Society for Electrical Development), that one year ago there were "not 20 per cent. of the houses within reach of central station service that were even wired, and of those houses wired, not 1 per cent. were using electricity to the fullest extent." If the gas companies renege on the houses that are now piped and on those new houses that should be piped, they are going to force electric service on consumers before they want it, and perhaps before the electric companies can take care of it. The electric companies, just now at any rate, seem averse to making extensions. If the gas man is disposed to cut out gas lighting, he ought to do it gradually, and give the consumer an opportunity to prepare for the change over. I remember going over some

photographs a short time ago, taken in one of our Eastern cities, of "all-gas kitchens." A great deal was said about the wonderful work which had been done on gas kitchen installations, but some of these "all-gas kitchens" had *kerosene lamps hanging on the walls*. Even though this was in combination territory, I do not believe there would have required as much sales effort to replace the kerosene lamps with good gas lamps as was brought to bear on the "all-gas kitchen." It was merely that the salesman was not required, or may have been forbidden, to encourage the sale of gas lamps.

A question which Mr. Cohn referred to and to which other references have been made, would seem to be within the sphere of this association, that is, getting good gas at uniform pressure, of uniform quality, and of uniform specific gravity. This is important not only for gas lamps, in which not all gas men are interested, but is also of importance with fuel burners. The American Gas Institute is surely deeply interested in the manufacture and distribution of a means to secure uniform service in the appliances in use. The gas engineer is not through when he has turned a something into the mains at a pressure greater than atmospheric pressure. In looking over the situation, it seems to me that there is an opportunity for excellent work by a committee of this association on light and illumination.

The National Commercial Gas Association is primarily an association of salesmen and sales managers, men whose business it is to develop the sales side of the field, to place in service those appliances which you engineers approve. Fuel burners are approved by the American Gas Institute, but no attention has been paid to the mantle burner. This field is large, or larger than the fuel field, and is, I believe, at the present time carrying a larger investment in cheap materials, in gas service depreciating opportunities, than the fuel field ever afforded. The National Commercial Gas Association has a very insecure hold on lighting, and without the proper appliances, can do but little without the interest and backing of the engineers in the

American Gas Institute. If the engineers do not appreciate the importance of gas lighting, then they should either agree to forget it, or to appreciate it. There are still many thousands of houses and buildings that have never been wired, and these buildings are not being given the lighting service that they ought to have.

Of course, the gas lamp manufacturers are blamed. It has always been interesting to me to hear gas men bewail the crudeness and high cost of our gas lamps and fixtures. All are looking for 100 per cent. performance. The electric man does not get 100 per cent. His appliances are not 100 per cent. perfect. They are not 100 per cent. trouble free. I know gas men who are to-day taking to the woods on outdoor lighting because of the nitrogen filled electric lamp. If they were really familiar with the situation, they would not give up until they had to, and considering the many thousand dark places available, it may be 50 years before that time arrives. The fact that the commercial man is not in a position to take care of all these distribution matters, has been proven in not a few installations where the engineers have not interested themselves beyond the consumer's meter, and we find locations where four or five arc lamps have been supplied from a  $\frac{3}{8}$ -in. line. No gas engineer would permit such an installation.

There are no standards to-day as regards quality of either mantles or lamps, gas or gas service, all of which are matters logically up to the American Gas Institute. (Applause.)

MR. T. J. LITTLE (Gloucester, N. J.): There are certain men pretty high in the electrical industry who believe that gas lighting could be greatly increased in extent if greater sales energy were placed behind it, and furthermore, if this had been the case in years gone by, it would have been very much more difficult for the electric light to have gained so great a headway. This may be true in many localities.

MR. W. J. CAHILL (Utica, N. Y.): In reference to the volume of gas sold for lighting and fuel purposes, I have some information that may be of interest.

We have a two meter system. We charge \$1.00 for fuel and \$1.10 for lighting. During the past four years our lighting load has remained stationary. The gain has been along the line of fuel; that is, for industrial appliances, gas ranges, water heaters, and so forth. We canvass for gas arcs, both indoor and outdoor. We have maintained a separate shop for piping old houses, that is, houses that were built years ago and had no means of gas lighting. We have also followed up the architects to give us a chance at piping houses. We canvassed every year for incandescent gas lighting, and with all that effort and work, our lighting load has remained practically unchanged since 1910. Our increase has been along the line of fuel. In my home, I have an automatic heater and a gas range used twelve months in the year. I have three incandescent lights, all of which I use, and the balance are open flame. The lighting bill is about \$5.00 and the fuel about \$7.00 per month.

Mr. Cohn stated that his 6 P. M. to 6 A. M. lighting output continually shows an increase. Is that not occasioned somewhat by the fact that during the past two or three years the automatic water heater has come into more general use? That means fuel gas. Also, gas ranges have displaced coal ranges. I think our situation in Utica is just the same as anywhere. We have carried on the same canvass for new business practically as any of the other gas companies. I will not say we are the best; I do not think we are the poorest. We are also up against the very stiff proposition that our company has water power for the generation of electricity, which it sells at a very low rate, on a sliding scale. That makes it difficult to secure factory lighting, or anything like that, for gas. I just mention these figures as to the proportion of fuel and light sales, based on the consumption of 1910, 1911, 1912, 1913 and 1914, because I thought they might be of interest, and because if you have two meters, you have a very easy method of computing the volume. Our output was 460,000,000 ft. in the year 1910.

MR. COHN: I do not want Mr. Cahill to mislead any one here unwittingly on the subject of gas lighting. The very first thing he tells you is that they have two rates there, and the highest rate is for gas lighting. Why should there be any difference? They start right out with a discrimination against gas lighting, and then tell you they cannot get the gas lighting, but they do get the fuel. I will ask Mr. Cahill to tell you how many incandescent gas burners he sold during the last 12 months?

MR. CAHILL: I dare say several thousand.

MR. COHN: In Baltimore we have sold 50,000.

MR. CAHILL: Compare the size of the towns.

MR. COHN: You sold 2,000 against our 50,000. Is the relative difference in population of Baltimore and Utica that? What is the population of Utica?

MR. CAHILL: Eighty-five thousand. I said several thousand lamps, not 2,000. What did you displace by the incandescent lamp, open flame burners, or was it all new business?

MR. COHN: The population of Baltimore is 600,000.

MR. CAHILL: What are your electric rates?

MR. COHN: The maximum rate is  $8\frac{1}{2}$  cents. What is your maximum electric rate for residence lighting in Utica?

MR. CAHILL: Ten cents.

MR. COHN: I am talking about residence lighting because there is where we are going to get the bulk of our gas lighting.

MR. CAHILL: What is your minimum rate?

MR. COHN: One cent.

MR. G. S. BARROWS (Philadelphia): Referring to Mr. Cahill's statement that the lighting output has remained the same, does he mean the lighting output per meter, or the total lighting output? If it is the latter, then because of the increase in meters, the use of gas for lighting per meter has decreased.

MR. CAHILL: That is my idea; the total lighting load remains the same.

MR. MACBETH: I would like to ask a question. There are a great many gas companies throughout the country that do not have show rooms, do not have campaigns and do not have salesmen. The Utica company has been pushing hard; it has been running a campaign; it has salesmen out and has a great show room. In view of the experience in Utica, I would like to ask the gentleman from Utica, what, in his opinion, would be the effect on gas lighting in Utica if they did not have any sales, if they left it as it is left in a great many cities throughout this country, now that he has such excellent figures on what they are doing.

MR. CAHILL: I would say it would show a decided decrease. Furthermore, the architects throughout the country, the ones I have come up against, seem to be prejudiced against gas for lighting. They want the piping there to get the fuel installation and possibly some emergency lighting. Possibly it might be different in other localities, but I think we should be very frank and tell conditions exactly as they are.

THE CHAIRMAN: We want a frank discussion.

MR. J. P. HANLAN (Newark): I think we are very fortunate this afternoon in having as our chairman a man who has so ably marshalled the facts in connection with illumination conditions as they present themselves to-day, and who has also so fearlessly expressed himself, and I am glad we are getting action, as evidenced by the last debate.

I am an optimist so far as gas lighting is concerned, and I believe that securing our share of it is largely a selling proposition. We have the service, and it has been proved conclusively that where the business is gone after, it can be obtained. Our sales this year of gas arcs and large single unit lamps, for instance, are over 1,000 ahead of last year, if my memory serves me right.

In view of the fact that you have asked for expressions of opinion that were not altogether favorable to gas lighting progress, I relate this incident. I was in the salesroom of one of the large fixture manufacturers in New York City, about

six weeks ago, and I happened to know one of the men there very well, who I know would not tell me anything but what was right. He said, "See that man just going out, Mr. Hanlan?" I said, "Yes." "Well, he represents one of the largest dealers in fixtures in the metropolitan district, and he has just told me that they are going out of the gas fixture end of their business entirely."

I would like any of you to go to John Wanamaker's and attempt to find many gas reading lamps. All of this means that, so far as some of the dealers are concerned, they are pushing the thing that they can sell the easiest, and the easiest thing they can sell, apparently, in these days is not a gas appliance. Now, it behooves us to push the article we want to sell, because the other fellow will not push it for us. Take this building here, we cannot make a display of any of our appliances, as I understand it. Go to John Wanamaker's and ask to see a portable gas light and it cannot be seen lighted. Yet there are just as fine portable gas reading lamps as electric lamps. We have both on display in New Jersey, and I defy any man to tell me which is the gas and which is the electric lamp, so far as appearances are concerned. That does not do us any good unless our customers know it. And that is where the selling end of the proposition comes in. The most of our gas lighting business which has been lost—if it has been lost—has been lost either through our fault or our indifference. We spend all sorts of money on gas works and systems of distribution, and we are very sure that the meter that is put in for the customer is all right to give him service, and then let it go at that, in a great many cases. What is the outcome? The customers are the prey of every peddler who goes around, and no matter how good your gas or system of distribution is, if the appliance the customer has to use the gas with, is not all right, what good is our gas to him? What good are our mains and our fine systems of distribution to him? It doesn't mean anything, unless the incandescent lamp he is using is going to give him service.

I would like to second the suggestion to have a committee consider the standardizing of lamps and mantle. As I said this morning, I believe the Institute should pursue this investigation of gas illumination. We are just as much interested in gas illumination as any other association. The engineer should be just as much interested in proper illumination as the agent or the manager. It is his business, as it is the commercial man's business. He gets his glory and compensation from the same source. Here is what I consider to be a practical suggestion as to a method of getting and holding gas business. That this association co-operate with the National Commercial Gas Association, if the directors see fit, and let us see if we cannot get a proper combination fixture. Since people are putting in combination fixtures, we cannot stop them. To-day the houses are being wired and piped in our territory. The good houses are being piped and wired and combination fixtures are being put in, but what good is it when combination fixtures are put in that are so close to the ceiling, that you could not light the gas in the combination fixture if you wanted to. Because of these combination fixtures, we are not only losing lighting, but are also losing heating business. There are places in any large city where you could not put in a gas heater in the parlor or dining room if you wanted to. I do not know whether any of you men appreciate that fact or not. The only way you can get a connection for a gas heating stove is to put a connection near the ceiling. We now have a very creditable combination fixture for store lighting, in an indirect fixture, just perfected. Having such a fixture, will not do any good unless the gas men take hold of it and push it. The electric men have had to fight us too long, to come around and try to help us save our business, when they have been trying to take it all the time. Let us get busy and get a proper combination fixture, if there is such a thing. As a matter of fact, there is no good combination fixture for store lighting, except this new semi-indirect fixture.

Let us get together and have new buildings piped, so that we



will have installed in each room a fuel outlet. The electric men are doing it, and have hard work to get inside baseboard outlets. We have a device that is just as good as any electrical device, for the purpose of making an artistic connection for a portable gas reading lamp or portable stove or chafing dish, but we must exploit it to the public.

THE CHAIRMAN: That is a good argument for standardization.

MR. G. W. THOMSON (Chester, Pa.): I believe by using the Toronto system of maintenance, the lighting business of our companies would grow, especially in the residences. Toronto last year, I believe, went out on a system of door to door inspection to take care of that business, which I think is absolutely necessary, if Mr. Hanlan is right in reference to our customers being subject to door to door peddlers all the time.

In speaking of combination fixtures, I don't know whether Mr. Hanlan is acquainted with the fact or not, but I believe one company in Delaware has sold them for the last two or three years, and has handled their fixture business very successfully. There are a lot of companies that do not handle combination fixtures of any kind; they leave it up to the customer or operator; therefore, they are subject to any fixture, mostly electric.

On the subject of gas for emergency only,—that is not true in the Wilmington situation. In Wilmington, gas fixtures are installed in 80 or 85 per cent. of all the houses built, which is a very creditable showing. The combination companies have had a whole lot to do, I believe, with the feeling that gas for lighting is losing its day. I do not feel that there are very many straight gas companies that have that feeling. I think most of them believe that they are showing an increase in gas for lighting. We are showing a good increase of gas for lighting. We are losing some of the old residences and we are losing some of the new combination fixtures, but we are making up for it by selling gas in 70 per cent. of the new houses,

and in some old ones that we have never had heretofore, displacing other methods.

MR. R. F. PIERCE (Gloucester, N. J.): The future of the gas lighting business may be best estimated by the past. The amount of lighting service represented by each year's output of incandescent mantles, in so far as it can be estimated from available data, indicates that the amount of gas lighting service performed by the gas mantle has increased about 250 per cent. in the last seven years, and that, at the present time, it is substantially greater than the lighting service given by electricity. I think that the percentage of increase over the period of seven years will compare very favorably with what has been accomplished in electric lighting. We all know that when gas lighting is properly done, it is a very satisfactory means of illumination. There is very little indeed that the most captious critic can say against it. It is practically immune from competition in so far as that is possible, and if there is any backward step in any situation in gas lighting, it will (I will not say invariably, but almost invariably) be found to be due to the fact that gas lighting is not done in the most modern way, and it is not pushed vigorously. Mr. Cohn particularly touched upon the necessity of giving good lighting service and doing the thing right. Now, in the National Commercial Gas Association, we have, for some time, come to the conclusion that not only the lighting business, but every department of the gas company's activities, demands the education of each individual having to do with the service, not only the salesmen, the accountants, the fitters, but every man who touches upon the business at any point, whether it be at the works or in the office. We realize that there are two things that make a man effective and efficient, and that make a business effective, efficient and profitable. Those two things are enthusiasm and knowledge. We believe that the best way to engender enthusiasm is to educate the man. A man who knows his subject is always enthusiastic upon it, and a man who is not enthusiastic, generally knows very little about the subject. Where we find

a lack of enthusiasm with respect to the subject of gas lighting, it will nearly always be found in a man who has a very limited knowledge concerning what constitutes a proper and satisfactory application of light for illumination.

The educational work in which we are engaged, as our Chairman has stated, resulted this last year in an enrollment of 3,850 men. It was generally predicted that the subject of lighting would not receive a great deal of consideration by the men, that the lessons on lighting would receive scanty attention and would not be carefully studied, because the men either lacked interest in them or considered the subject difficult. Two out of ten lessons were devoted to the subject of lighting. The second lesson on illumination was by far the most difficult in the course. Over two-thirds of the men who answered the first paper, answered that difficult paper on lighting, and 90 per cent. of them got the highest obtainable mark, made probably a better showing, all things considered, than in any other branch or study, indicating that these men have an interest in lighting, and that if they have the opportunity, they will equip themselves with knowledge on that subject which will make them effective salesmen, and result in the increase in gas lighting business.

Now, the National Commercial Gas Association reaches a very important and considerable class of men. The membership of the American Gas Institute represents a class of men whose active co-operation must be enlisted, if the best results are to be obtained in an aggressive campaign for gas lighting business. That interest can only be engendered and sustained by an active presentation of the subject of lighting, and added activity on the part of the Institute as a whole. I would recommend to the Institute the advisability of a joint committee with the National Commercial Gas Association to deal with the subject of illumination in its relation to the gas industry. I believe that this would accomplish certain very desirable things that can be accomplished in no other manner. I believe that it is necessary that this interest should be stirred

up and maintained; that every man in the industry should be educated along the lines of what constitutes proper illumination. It is just as important to educate the president and the engineers of the gas company as it is to educate the fitters and the salesmen, and, in some cases, it is as greatly needed. I would recommend for your serious consideration a step of this kind.

MR. C. H. STONE (Middletown, N. Y.): I am a rather rabid supporter of the calorific standard. I want to say just a word as to what was said on the subject of lights. I don't believe there is a gas man in this room, with possibly one or two exceptions, who can tell the difference between 570 and 620 B. t. u., when the lamps are properly adjusted. In the second place, I think you will find no company has made a sudden reduction of heat units on account of change of standards, without at the same time readjusting the burners. So that, personally, I do not believe there should be any diminution of gas lighting on account of the diminution in the heating power of gas.

I am speaking for a small company, and, personally, I am interested only in the gas end. I am enthusiastic over gas lighting myself. My house is entirely lighted by gas, by the most modern method I could find at the time of installation, and I eat, sleep and talk gas all the time. We have an enthusiastic, intelligent force, and we have done everything we could to interest the people. The two men who have that work in charge are able and zealous. I have often caught them on the street corners talking gas to people when they were supposed to be enjoying their day off. We have been to the architects, to the plumbers and to the contractors, and I don't know where else we can go. In the last year, to the best of my knowledge, there has been in the city of Middletown, only one house piped for gas lighting. Let me ask you, what can you expect for gas lighting if that is the showing you get. In the new districts, the electric wires are placed, and the gas man does not get a show to secure anything at all after the

electricity is in. I realize the difference between the expenditure for the electric lines and for the gas mains, but what kind of a chance do you stand, to get the gas lighting in a new district, when the houses are already wired and the fixtures all in. They are not going to put in gas fixtures, with the *possibility* that a main is going through there five years later, with no *certainty* that it is coming at all. I would not do it myself, and I don't believe any customer would do it.

One other point has been brought up with regard to pilot lights. I believe there are four things which to-day are holding back gas lighting. The most vital thing of all is the inability to light gas with the same ease and certainty with which you can light an electric lamp. You cannot do that with pilot lights. There is no way to do it, that I know of at the present time, that is applicable to the ordinary house. The pilots in our town are giving so much trouble that there is no use selling gas arcs. When you go to a customer he says, "Here are 25 per cent. of your arcs which cannot be kept lighted," and yet we look after them once a week and some of them, every day. Can we give them any more attention than that? You may say that the quality of gas is at fault, but if this were so, why do 75 per cent. of the arcs give no trouble at all? Why does one lamp in a store operate for a year without ever losing its pilot light, and another one in the same store within 10 ft. of it, off the same supply, and used to the same extent, have its pilot out every day?

The second thing is the smoke. You can adjust the lamp perfectly, and of course, in my own house I have no trouble with smoke, but it is a fact that a gas lamp is capable of readjustment, and will be adjusted by the consumer just so long as he thinks he is going to get better light, and the chances are that at some time or other the lamp will smoke, and the result is, the gas industry gets a black eye on account of the black ceiling.

The third factor is the heat. You might as well be frank about it, a gas lamp gives heat. You cannot persuade the

customer that you can sit within 3 ft. of the gas arc and not feel the heat. I feel it myself. That is a thing which militates against gas lighting.

And the fourth thing, is the feeling which is prevalent and which is, I think, due mostly to the very effective advertising of our electric brethren, that the electric light is modern and up-to-date. I don't think this is important, but in my own case, it is extremely prominent, and nine times out of ten, they put that up to you,—gas lighting is out of date.

Until you can change those first three items, you cannot push gas for light successfully against electricity, at a reasonable price. I don't want to be a pessimist. I am very strongly on the other side. I would not have equipped my own house for gas lighting if I had not thought it was the best thing, and I am absolutely satisfied with it. I have the finest light in the city of Middletown, and I tell everybody that I can do anything with my gas light that they can do with electricity. I can light it from downstairs and upstairs and everywhere else, by pushing a button. I can get a better quality of light and more light for my money, and in every way it is satisfactory. But those three points are brought up against me every time, and I believe they form the greatest obstacles to the progress of gas lighting.

MR. W. J. McCORKINDALE (Wilmington, Del.): For Mr. Stone's benefit, I would like to state that, while his two assistants may have the enthusiasm, there is something else that is lacking, and if I had that same condition, I believe I would not let those men go, but I would give them work in some other department. In our discussion, great stress has been laid by so many speakers about the low cost of electricity—

THE CHAIRMAN: Cannot you give specific answers?

MR. McCORKINDALE: I will do that. I am coming to that in a minute. We have at a number of our stores a 2-cent rate, simply because at one time we had two competing electric companies. Some years ago, they had to go in and get long term contracts for five years, and took them at a 2-cent rate, and

many of those contracts are still in use, so we have had our uphill work also. I doubt if 5 per cent. of the buildings built in Wilmington anywhere within the city limits are erected without gas piping being installed. I do not know of any buildings in the last year and a half that have been erected in Wilmington and not piped; many of the houses are fixtured for gas only, and the rest of them are combination. There is no question at all but you can get the business if you go after it rightly.

You speak about taking the matter up with architects. Some architects you can handle with kid gloves, and on others you have to use a sledge hammer. We have a building being erected at the present time, our joint city and county building, which is to cost \$1,000,000; all the plans were drawn, everything was arranged for, but not a foot of gas piping was going to be in it. Our company got after the matter, could not do anything with the architect, and had to go after the Levy Court and City Council. We fixed it up so that now every room in that building will be piped and every fixture in that building is to be a combination, and we expect to sell the fixtures. (Laughter.)

Now, regarding the smoking of the ceiling, pilot lights, and those things, those are local conditions and can be remedied. Mr. Thomson was kind enough to mention our fixture business. We sell about 85 per cent. of the fixtures sold in Wilmington, notwithstanding we are close to Philadelphia and large fixture houses. We put in combination fixtures which place electric light and gas on the same plane. Looking at the fixture, both the gas and electric supplies look like chains, and you have to go up close to them to tell which is the real chain and which is the pipe. The consequence is, we are getting our share of the lighting business. We made a canvass about six weeks ago of twenty-three houses in a building operation with combination fixtures, and seventeen of the houses were using gas exclusively, two of them were using electricity only, and the balance were using both gas and electricity.

We use inverted lights, so that you cannot tell the gas from

the electric. We have our pilot troubles, but they are not serious enough to interfere with our lighting business. We have overcome a great deal of that by having a house maintenance department. We start at 20 cents a light and reduce according to the number we have. That service goes on for 12 months in the year, and if a person telephones us they want their pilots overhauled or additional mantles put on, we look after it.

Regarding the smoking of the ceiling, of course, on the upright lights you will get it. On the inverted lights you will not get much. You will find that a steam pipe draws up dust and makes a mark on the ceiling, and an electric lamp does exactly the same thing.

MR. MACBETH: There are one or two points in the discussion of two or three of the speakers that I would like to refer to.

There is one point that comes up constantly about the high price of gas fixtures, and the difficulty gas men have in getting satisfactory fixtures at their own prices. At the same time, we have men going out of the gas fixture business, because the gas man won't pay anywhere near the price for a similar fixture that the electric man will pay. Much of this agitation has been due to lack of judgment on the part of the gas man. The fixture man is not playing favorites, but is catering to that branch of the trade which appreciates his efforts, and we cannot blame him for thinking that the gas man's money is no better than that he receives for electric fixtures.

Mr. Cohn, and also Mr. Stone, referred to pilots. I would like to ask any of the engineers here if a  $\frac{3}{4}$  in. \$3 governor is not good for 30 years, more or less? I have used gas lamps for many years, and while in one house, a short time back, used ten or twelve burners all equipped with pilots. I don't believe that during two years' use, there were three of the pilots out. I remember one occasion when we were away from the city for about six weeks, with the house closed, there was one pilot out when we came back, and we noticed that, not



from any odor, but when we pulled the by-pass chain. At one time I attached a pressure gauge in my bathroom, noting it at different hours of the night and day, and rarely saw a change greater than a tenth or two. The house was in a section of Philadelphia where they had district governors and where the mains were ample. That is the point. If we can interest the engineer in ultimate service, it is my opinion that pilot troubles will be found to be due not to the pilots, but to bad service, changing of specific gravity, etc. Pressure changes can be taken care of with inexpensive governors.

Mr. Stone brought out a point at the Richmond meeting last year. I may be wrong, and if so, I hope Mr. Stone will correct me. In his paper on the percentage of mantle burners used in Middletown, the question was raised as to the number of these burners which had been purchased from dealers and in the 5 and 10-cent stores. As I recall the discussion, this number was comparatively large. If that is true, the Institute Committee on Standardization of Lighting Appliances will do something if it succeeds only in properly labelling the cheap stuff.

To-day we have little beyond personal experience to guide us. You can not go by prices. I saw a mantle box recently brought to a store by a man who had apparently had a satisfactory experience; he said "I want another mantle like this; it is a 75-cent mantle, but I paid 50 cents for it." The dealer was not familiar with the brand, and as it had a Pittsburgh address on the label, the box was finally sent to Pittsburgh for a duplicate order. The Pittsburgh dealer not caring to be bothered with the box, soaked the label off, and was surprised to find another label, the original one, also on the box. This label identified the mantle as one of the 3-cent variety, made by a well-known manufacturer for the push-cart trade. So that the price does not altogether fix the quality of your mantles.

Mr. Stone mentioned the heat troubles with gas lamps. Complaint from heat, if justified, is usually due to over-

lighting. As a matter of fact, the heat from gas lamps is not greater below the lamps than from carbon filament electric lamps of equal light output. Comparatively recent tests on this point were buried not so long ago in the proceedings of the Institute. It is true that more heat is liberated by a gas lamp, but a large portion is converted and diffused into the upper air in a room. It is in matters of this kind that the Institute could be most helpful in settling beyond question, so many of these points of so-called disadvantages which are largely matters of conversation only. To settle it, is the main consideration. I recall a discussion on gasoline competition, some time ago, at a gas men's meeting. One of the speakers said that in his city there had been no trouble from gasoline plants for some time, and when pressed for an explanation, he remarked, that the electric light man and he had simply gone down to the city officials, and had an ordinance prepared and passed.

(At this point, Mr. Barrows read Section VI—"Lighting Appliances"—of the report of the Committee on Utilization of Gas Appliances.)

THE CHAIRMAN: The recommendation of the Committee on the Utilization of Gas Appliances with reference to the standardization of lamps and mantles, is rather similar to the one Mr. Pierce voiced. Perhaps they are sufficiently so to warrant their being merged as a recommendation agreeable to both proposers. If, therefore, Mr. Pierce and Mr. Barrows will jointly prepare a resolution, we will vote on it. You understand that these section meetings have been arranged in such fashion that when, out of section discussion, there grows a useful idea for the Institute, we can, by vote here, give it section approval and recommend it to the Institute. I will be glad to entertain the resolution when presented.

MR. LITTLE: One of the previous speakers referred to troubles that he had with pilot ignition, stating that it was impossible to maintain pilots in his town, even though he adjusted them daily. His trouble was, of course, not due to

faulty lamp construction, but to an oily film deposit upon the point of the pilot adjusting screw. This film, even though it be infinitesimal in thickness, will be enough to close the gas-way leading to the pilot tube. I have been called upon to remedy troubles of this nature before, and have successfully used a small filter box placed just ahead of the pilot adjusting screw, so that the oily deposit is removed from the gas before it reaches the screw.

There is a distinct advantage in pilot ignition of gas, for the reason that the slight illumination furnished by the pilot flame is sufficient to guide one to the appliance when used in a dark room.

Electrical inventors have designed electric wall-switches with luminous front plates, and also luminous balls for their pendant fixture sockets. These glow very faintly at their best, and sometimes, not at all. The illumination given by these devices depend upon the light absorbed during the day, and unless they are exposed to considerable light in daytime, there is little, if any, illumination given off at night.

DR. H. E. IVES (Philadelphia): The Chairman in his opening address called for pessimists and optimists. It seems to me we have heard chiefly from two extreme classes, first, those who say that gas lighting is not declining (they may be classed as the blind optimists) and, second, those who say it is declining, but there is no hope for it (they are the blind pessimists). Now, there is an intermediate class who believe gas lighting is declining, but believe it can be saved. It is to that class that I belong.

I do not believe we should allow ourselves to be lulled into a feeling of security on the basis of the number of houses piped nor the number of combination fixtures sold. What we need are direct figures on gas lighting; not indirect inferences, on the interpretation of which no two people agree. I know of many cases where the combination fixtures which are quoted are of such character that it is impossible to burn an incandescent mantle on them. I know of miles of streets where the

new houses are piped for gas, it is true, but they are being wired for electricity, and not one occupant in a hundred thinks of using the gas for lighting. We should, I think, start this discussion with the frank acknowledgment that gas lighting is in bad health, and proceed at once to study what we can do to help it.

The Chairman has pointed out, that part of this field is already being covered by the National Commercial Gas Association. This committee should then decide what it is that the Institute can do without intruding on the work of the Association. It seems to me that the real field of this Committee on Illumination is to serve as the source of information to the Institute on what things will be necessary to do in the manufacture and distribution of gas, in order to hold gas lighting.

What kind of gas and what method of distribution may we expect to be demanded by future developments in gas lighting? We have heard certain defects in the service given by lighting units characterized as "gas troubles." Should the gas manufacturer and distributor be reproached for the deficiencies of their gas, when there has been, apparently, no well-directed effort to keep them informed on what the latest developments in burners call for in order to secure the best efficiency? And is not the time past when the gas engineer can say "Here is the gas, now use it"?

What must we look forward to in the not distant future? We have already struck a condition of approximate equality in the efficiency of gas and electric lighting. We may expect both to increase in efficiency, perhaps at approximately equal rates. Gas lighting is not hopeless, viewed from the efficiency standpoint, but it is undoubtedly weak on the score of convenience, cleanliness and reliability. Let this Committee report next year in what manner these defects may be reduced by the gas engineer. Perhaps we must have cleaner gas—this concerns the manufacturer. Perhaps we shall have to come to high pressure distribution with house pressure regulators—this concerns the distribution department. But the important point

is that the members of the Institute should keep in touch with all changes in the requirements for gas for lighting purposes.

I suggest that the function of this Committee be to render each year to the Institute a report, this report to point out what the gas engineer must do as his share in holding and increasing gas lighting.

MR. E. N. WRIGHTINGTON (Boston): In what Dr. Ives has said as to the duty of this Committee, it seems to me he has struck the key note, rather than the previous speakers. The previous speakers start talking about pressure and B. t. u., and end with the selling of the appliance. Mr. Hanlan says the reason he does not sell gas portables is because the people do not know how good they are. That is a selling problem. Another gentleman over here recites the disadvantages of gas from the customer's point of view. Those disadvantages have got to be solved, because there are other advantages which offset them. This is so much a selling problem, that it seems to me it is primarily the part of the National Commercial Gas Association's duty to undertake this kind of work. When it comes to a question of what the engineer can do to help to put gas lighting on a better plane, then it seems to me the committee is getting into a kind of work which is just what it should perform, and the kind of work the commercial man cannot perform. Most of these men we have heard here are commercial men. They have looked at it from a commercial point of view. There is a point beyond which the commercial man cannot go. That is to say, in engineering matters, the engineer should be the man to decide. But when it comes to taking up in a meeting like this a discussion of the commercial aspect of it, it seems to me, we are spreading the energy of these commercial men over too many associations. There is the American Gas Institute, the Illuminating Engineering Society, the National Commercial Gas Association. Their fields are distinct and different, but the same men frequently are trying to do work in all three, and it is very difficult for a man to go and give any particular time to association work.

He is occupied by his own particular job in his own locality. If the commercial man tries to spread his energies over the Institute and over the Illuminating Engineering Society, he is going to waste some of those energies. We all know this problem is big enough from a selling point of view to take all the time our commercial men can spare in it, so I think the joint committee would be an excellent idea, provided the part played by the committee of the Institute was confined to the engineering part of it, because if it is spread over both the engineering and the commercial, you will get into trouble again.

MR. BARROWS: Referring to the recommendation for a joint committee, it seems to me that better results will be obtained if two committees are formed, one from the Institute and one from the National Commercial Gas Association, with the understanding that these committees are to co-operate.

The questions involved are numerous, and among them will be found some relating to the engineering side, which will be of little interest to the commercial men and which can be better solved by the engineering men, and some which will be of but little interest to the engineering men, and which can be much better solved by the commercial men.

Each committee may then do its own work, and before the final reports are submitted, they may be gone over by the two committees in joint session.

If it is decided to form a joint committee, I believe that sub-committees of this joint committee should be formed, one to consider the commercial questions and one to consider the engineering questions.

I think if we change the wording of Dr. Ives' motion, so that it will call for improvement of lighting conditions from the engineering standpoint, and in this shape place it formally before the Institute, that this is all the action necessary for us to take.

Undoubtedly, if a committee is formed, it will work in very

close co-operation with any similar committee of the National Commercial Gas Association.

MR. W. H. GARTLEY (Philadelphia): I want to say that I think there is a great deal for the works to do in the betterment of gas service and gas lighting. I said in my presidential address that the idea had now been pretty well distributed among State Utility Commissions, that the attempt to force gas companies to carry a very high candle-power with the consequent high heat units would, on the whole, for all purposes for which gas was used, be found to be a misguided action. Some years ago, I was present at the Bureau of Standards, in Washington, together with a number of gas engineers who had been invited to consult with the Bureau regarding the regulations and the standards for their Circular No. 32. A number of the engineers, men of experience, took the position that it was better for the consumer if the gas had not over 570 heat units instead of 625 or 650 heat units.

The statement was made that a water gas of (say) 22 candle-power, equivalent to about 650 heat units, is so heavily laden with condensable hydrocarbon vapors absolutely necessary in the manufacture of such a gas, that in the colder climates of this country difficulties are experienced with it that would disappear if a heating value of 570 replaced it. The smoking of ceilings would be very much less; stopping of pilots would be less; the regulation of air mixers would be reduced, while in the gas for the kitchen and for a majority of other uses, as well as in the mantle, the reduction in heating value would scarcely be noticed in the results obtained. I believe that this argument at that time was not accepted by the Bureau, but the truth of the statement is becoming more generally accepted, and at this time, two of the State Commissions have adopted a value of 750 heat units. No State Commission has gone over 600, but most of the gas companies in the larger cities and in the medium sized cities, are making gas of over 600 units, probably because municipal laws or specifications in franchises require that the candle-power, and consequently, the

heat units shall be kept up to a quality higher than those companies now know to be of maximum benefit to the consumer.

Then again, there has been a great improvement made in the question of the total sulphur content. I believe if we could succeed to-day in getting all over the country a gas with 570 heat units and no sulphur or practically no sulphur—when I say “practically no sulphur,” I mean two grains—I believe we will have done a great deal to give satisfaction to the enormous number of consumers who now use gas and will continue to use gas. (Applause.)

MR. MACBETH: Just one point occurred to me in connection with the discussion of Mr. Wrightington on the desirable personnel of the Committee. I can see no reason for courting complications, nor yet the necessity for a joint representation on such a Committee. Even the Boards of Directors of these associations contain members of the other associations, and I believe it would be hardly possible in making up this Committee, if any attention at all is paid to selecting men who have been at all in touch with committee work, to choose men, many of whom would be also members of the National Commercial Gas Association, the Illuminating Engineering Society, and even the National Electric Light Association.

I, therefore, make the motion if it is acceptable to the chair, that the report of this Committee be accepted and that a recommendation be made to the Board of Directors of the Institute that the Committee on Illumination be continued, and that the work of this Committee be along the lines brought out in the discussion here this afternoon relative to burners, and also distribution and gas qualities.

MR. WRIGHTINGTON: May I ask a question as to what this committee would do, as to whether they would confine themselves to the engineering questions, or discuss the special questions that have been discussed to-day?

THE CHAIRMAN: As I understand the motion, it is a recommendation to the Board of Directors of the American Gas Institute that the Committee on Illumination be continued,



its scope to particularly cover problems which have engineering features as contrasted with those which are commercial.

MR. WRIGHTINGTON: I would like to state, from a commercial point of view, a fact in connection with the conditions in Boston, a statement I have made in the Commercial Association, but perhaps some of the others would be interested in it. A year ago, or a little more than a year ago, in Boston, we made an actual count of the number of new residences which adopted and actually use gas for lighting purposes, either solely or almost exclusively, and that count showed  $87\frac{1}{2}$  per cent. of all the new buildings, new residences, put up in that 12 months. There has been a slight drop since, but last year was not a normal year, on account of the fact that there had been a very decided falling off in the number of building operations of the cheaper class, which is more especially the gas man's field. So that I think in Boston we don't feel that gas is a back number, when that proportion of new buildings are being equipped with gas lighting facilities.

THE CHAIRMAN: There are two points I would like to bring out. One is with regard to pilots. In the new form of blue flame or bunsen pilot there is little luminous flame, and, therefore, if it impinges on the mantle, it does not produce a carbon spot. At the point of impingement, there is a small patch on the mantle which is incandescent and which gives the low illumination in the room referred to; it also makes more difficult the extinguishing of the pilot, because there is a larger total mass of material which is at an ignition temperature. Besides this, when properly placed, it gives a perfectly soft ignition.

The other point that occurred to me was with regard to the reduction of sulphur in the gas and its possible effect in helping good service. I think that Mr. Brady is in the room, and he can tell us something of a test he made on the discoloration of ceilings and how the sulphur in the gas entered into that as a factor.

MR. E. J. BRADY (Philadelphia): About two years ago I

made a rather extended test on the effect of gas on the discoloration of ceilings and among the various gases we tried was a gas that was absolutely sulphur free. By "absolutely" I mean a small fraction of a grain per 100 cu. ft. Alongside of the lamp which burned this gas, there was one burning ordinary gas as it is sent out through the mains. They were Reflex lamps, exactly the same, and the entire equipments were brand new. We burned these two lamps for 850 hours, and the lamp that burned ordinary gas had a heavy accumulation of white deposit on the inside of the crown shell. The glass cylinder was covered with a sort of frosting. This could easily be washed off, but at the same time, it cut down the candle-power of the lamp. The inside of the crown shell of the lamp burning the gas containing a small fraction of sulphur, was absolutely clean, and had retained its polish. It could not be distinguished from a new and unused lamp. The glass cylinder was clean and had none of this speckled effect. That was the effect of 850 hours' burning.

THE CHAIRMAN: Wasn't there something about the discoloration of the ceiling that is connected with this?

MR. BRADY: Yes. The discoloration of the ceiling was very greatly reduced in the case of the lamp burning the sulphur free gas. There was some discoloration and that, no doubt, was due to the heat alone.

MR. THOMSON: Will Mr. Brady kindly tell us what kind of gas that was?

MR. BRADY: That was a mixed coal and water gas.

MR. GARTLEY: I would like to supplement one statement that Mr. Wrightington made with some very interesting statistics. In Philadelphia, we find that the percentage of gas sent out between the sunset and sunrise hours has not decreased in the last five years.

THE CHAIRMAN: Here is Mr. Macbeth's resolution. A recommendation to the Board of Directors of the Institute that the Section on Illumination be continued, and that the duties of the Illumination Committee be to investigate and

report on lamps, mantles, fixtures and piping and other engineering aspects of gas lighting.

(The motion was duly seconded.)

THE CHAIRMAN: This recommendation, as you have heard it, has been seconded. Are there any remarks? All those in favor of this will say aye.

(The motion was duly carried.)

### APPOINTMENT OF SECTIONAL NOMINATING COMMITTEE.

THE CHAIRMAN: As this resolution possibly may be acted upon favorably, it puts us in the position now of having to nominate three men from this section as candidates for Vice-President of the Illumination Section, for election in 1915. I would like to ask the nomination committee, now to be named, to report their recommendation of three names with due speed, and I will appoint as the Chairman of this nominating committee Mr. G. I. Vincent, and the other members Mr. E. N. Wrightington and Mr. Sidney Mason. We have with us this afternoon a gentleman who might be on the other side of the fence, although I think he has a warm spot in his heart for us, and he is doing work on a committee of the National Electric Lamp Association. It is a little piece of history that the appointment of a Committee on Illumination by the American Institute of Electrical Engineers was indirectly the reason for having a committee of a similar character suggested for this meeting. The nature of the work which has been done by that other committee or is contemplated might possibly be learned, and I would like to hear a word, if possible, from Mr. P. S. Millar, of New York, as to parallel work which is done by the committee.

MR. MILLAR: I am on the committee. I know it has confined its efforts to arranging for two or three papers on illumination at the annual convention. That committee has considered that the Illuminating Engineering Society is doing the illuminating engineering work necessary from the electrical

engineering viewpoint, and it has not been actively engaged in promoting illumination matters.

THE CHAIRMAN: In my Presidential address to the Illuminating Engineering Society, I stated my belief that it was the duty of that society to tell us what could be considered a standard type of fixture for a given room, and I did not care what room was chosen; you could take a bath room, or dining room or any other room. What would be considered the standard type of fixture? Who shall answer the question? The Committee on Presidential address, however, did not think that was the duty of the Illuminating Engineering Society. Now, just as the National Electric Lamp Association, and the Association of Edison Illuminating Companies have considered it a logical and legitimate field for their endeavor to work out a best form of street lighting, so we probably will have in this Institute and in the National Commercial Gas Association, committees which will work out what they consider to be proper methods of street lighting and house lighting and factory lighting. We have with us this afternoon—he is working on that committee just at present—one gentleman who is the chairman of the Committee on Indoor Lighting of the National Commercial Gas Association, and I am wondering whether that Committee contemplates standardizing illumination for different classes of rooms. Can any one answer for that Committee?

MR. T. J. LITTLE (Gloucester N. J.): I had that in mind.

THE CHAIRMAN: Do you think it a legitimate thing to undertake?

MR. LITTLE: I think that one suggestion alone would provide enough work for the committee for two or three years to come. In other words, I think it is a very large subject and a very important one. As I understand the situation, the standardization would fix a design for each room in the house.

THE CHAIRMAN: Yes, ultimately. I do not at present ask for every room in the house. Take, for instance, one single

room. Why have we come to the dining room dome? That is pretty general and pretty well agreed on. Is it the best type of illumination for a dining room? Is there any difference of opinion on that subject?

MR. LITTLE: Yes, there is a great deal of difference of opinion.

THE CHAIRMAN: Why can't we enroll eight men and put them in a room and make them agree as to some three methods that are best, so when you do put out something for a dining room, it won't be changed for the next two or three years? It seems to me a legitimate field of endeavor. Some one has said there are too many varieties of opinion and it cannot be arrived at. Yet it must be arrived at.

MR. P. S. YOUNG (Newark): By any one man I can see that a standard fixture for every room could be arrived at, but not by a number of men.

THE CHAIRMAN: Yet that is the very task which the Committee on Street Lighting has undertaken.

MR. YOUNG: I don't mean to say that might not be a good starting point anyhow.

THE CHAIRMAN: I would be very much interested to hear any further remarks.

MR. J. P. HANLAN (Newark): Among a number of articles detailing new business obtained in six months, published in a periodical by the National Gas Light Company, there is an illustrated one in which Mr. Lea gives his information from his standpoint and opinion, as to the articles to use and lamps and fixtures to use in various rooms in the house. And from what I have seen of them, the illustrations seem to be very practicable.

MR. J. P. CONROY (New York): From my standpoint, I would think that the dining room dome has become pretty generally universally used, and I think probably a committee might arrive at a conclusion that a room of certain dimensions,

(say) 10 by 12 or 10 by 10, would be about right for a two-light fixture, leaving a little range of space, and then a little larger room for three lights, and a still larger room for four lights, but it would be a very difficult thing to adopt any standard fixture for universal use.

MR. G. H. WARING (Charleston, S. C.): I would like to take exception to a remark made by Dr. Ives. He said one of the objections of gas was its unreliability. I think he meant the pilot. I think he said the gas. I would hate that to go in the record. We are always on the spot with gas. I was in a city the other day of 300,000 inhabitants, and all the electric lights, cars and everything electrical was stopped for 37 minutes.

DR. H. E. IVES (Philadelphia): Let me say in introduction, that I think the worst feature of the gas lighting situation is this reluctance to have facts go on record for fear they might hurt business. It is due to this that we can have such different views expressed on matters which after all are mere questions of fact. I think all the real facts about gas lighting had better go on record and go on soon, and so emphatically, that everybody will know what is the matter, and get busy trying to correct it. It is better to hurt business than to let it die through false modesty.

I stand by my statement that gas is unreliable. I need only refer you to the endless discussion here on pilot troubles to support this. Gas light is unreliable in the sense that it won't stay put; it needs constant watching. A friend of mine who owns a photograph gallery told me that he liked gas light very well but "Every time the pressure changes, I had to go all over my installation and readjust every burner. It was simply prohibitive, and so I put in electricity." Gas may be reliable in the sense that you can turn on an open flame burner and get a light, but surely we cannot hope to advertise gas by the fact that it will give a very inefficient light in the rare instances where more efficient and convenient means fail. Our problem

is to make gas lighting of such a character that the consumer will choose it for constant use.

MR. WARING: I am in the electric business as well as the gas business. I know the weaknesses of both. I have never had any trouble with keeping a properly constructed gas burner in shape and going, and we seem to be blamed here for all the complaints that are sent to the station. An electric station is a model. The trouble is with the manufacturer of the gas burner. If you buy a good gas burner, you won't have any trouble in keeping your pilot light going, provided you don't put it directly in the way of an electric fan or some undue exposure or something of that kind. We have had storms where the wind blew 105 miles an hour, and we did not suspend gas supply a minute, but the electric lights were all out in the street and the people were depending entirely on gas. I do not believe that this trouble is up to the central station. At the electric station, the appliance people come and help you out on these propositions and put the goods in your hands to solve your problems. The electric central station does not have to go out and show the manufacturers how to build their lamps. I claim that the electric central station doesn't give as good service as the gas central station. The gas people are not asleep. I resent that inference. All I have heard since I have been in this room is the statement that the gas man is asleep, he is making poor gas, don't keep up his burners, and the appliance man is making up-to-date stuff, and all he has got to do is to put it on and go ahead. It is not so. The electric appliance man comes and puts a good lamp in your hands and shows you how to sell it. That is the reason the electric central station is better equipped than the gas central station.

THE CHAIRMAN: Mr. Waring has troubles, but they are due to the lamps and not to the gas manufactured.

MR. WARING: I might say we have had troubles in the past until we found out the proper lamps to purchase. We don't have lamp trouble now.

THE CHAIRMAN: The result of this as I see it, Mr. Waring, would be that there is possible a specification of a standard lamp, or at least you can specify the conditions under which a good lamp can be built, because you have good lamps. You can get good lamps, and there are poor lamps. Then there is room for the committee to work, isn't there, just as there has been in all the other kinds of gas appliances?

MR. WARING: The only thing I took exception to was the fact the gas manager was making poor gas, and that that was the cause of all these troubles. I say the trouble is with the manufacturer of fixtures. He is not putting in our hands equipment to compete with the electric man. The electric manufacturer is putting in the hands of the central station, electric appliances to compete with gas.

THE CHAIRMAN: You missed one part of the discussion which really started this particular line of talk against the central station. One of the gentlemen who talked here did give a list of four troubles he had; and of those four troubles, three of them seemed to be up to the central station in his town. That is where this particular talk began. If you had been here I think you would have found it traceable to that rather than to the entire meeting.

MR. G. W. THOMSON (Chester, Pa.): I would like to know if any company representatives in the room are making periodical inspections of the house lighting system; whether they are giving free inspection and making a charge for material used. Is it done systematically in every house?

THE CHAIRMAN: Does any one wish to answer that question?

(No response.) Apparently not. I would like to hear from the Nominating Committee if it is ready to report.

#### REPORT OF SECTIONAL NOMINATING COMMITTEE.

MR. G. I. VINCENT (Des Moines, Ia.): Your Committee begs to report as follows for the three candidates: Mr. W. J.



Serrill, of Philadelphia; Mr. C. M. Cohn, of Baltimore; and Mr. C. O. Bond, of Philadelphia.

THE CHAIRMAN: You have heard the recommendation of the Committee. What is your pleasure?

The motion was made that the report be adopted. The motion was duly seconded and carried.

THE CHAIRMAN: I thank you very much for your presence here this afternoon in such numbers.

Adjourned, 5:45 P. M.

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